PATTERN MAKING

RITCHEY

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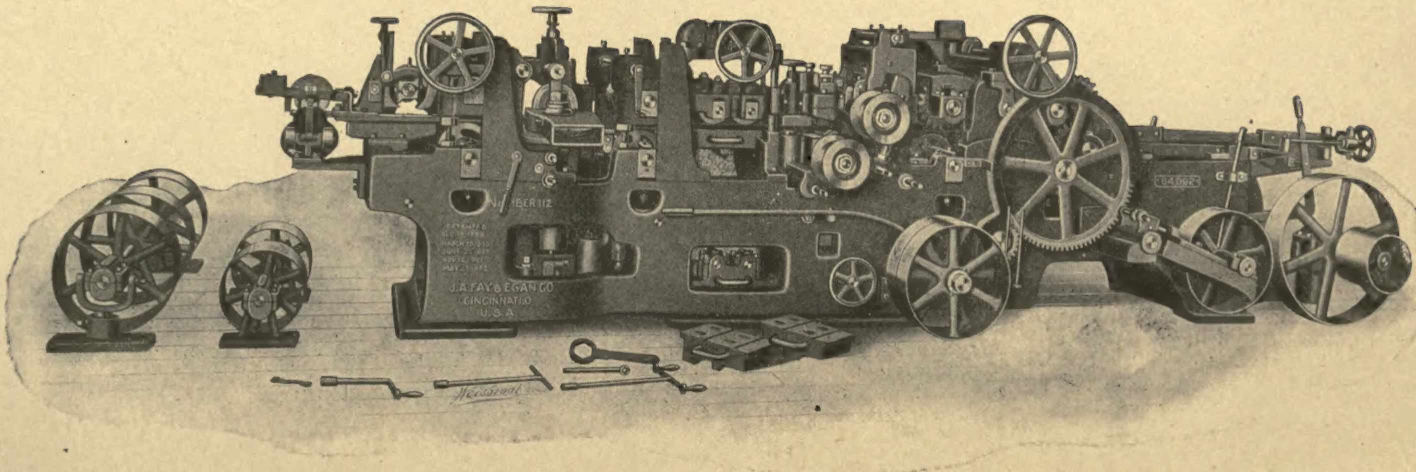

FIXED KNIFE PLANER FOR HARDWOOD FLOORING.
J. A. Fay and Egan Co.

Pattern Making

A Manual of

PRACTICAL INSTRUCTION IN THE USE OF WOODWORKING TOOLS AND MACHINERY, THE MAKING OF SIMPLE AND BUILT-UP PATTERNS, AND METHODS OF MOULDING

By JAMES RITCHEY
Formerly Instructor in Pattern Making, Armour Institute of Technology

ILLUSTRATED

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1908

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Foreword

IN recent years, such marvelous advances have been made in the engineering and scientific fields, and so rapid has been the evolution of mechanical and constructive processes and methods, that a distinct need has been created for a series of *practical working guides*, of convenient size and low cost, embodying the accumulated results of experience and the most approved modern practice along a great variety of lines. To fill this acknowledged need, is the special purpose of the series of handbooks to which this volume belongs.

¶ In the preparation of this series, it has been the aim of the publishers to lay special stress on the *practical* side of each subject, as distinguished from mere theoretical or academic discussion. Each volume is written by a well-known expert of acknowledged authority in his special line, and is based on a most careful study of practical needs and up-to-date methods as developed under the conditions of actual practice in the field, the shop, the mill, the power house, the drafting room, the engine room, etc.

¶ These volumes are especially adapted for purposes of self-instruction and home study. The utmost care has been used to bring the treatment of each subject within the range of the common understanding, so that the work will appeal not only to the technically trained expert, but also to the beginner and the self-taught practical man who wishes to keep abreast of modern progress. The language is simple and clear; heavy technical terms and the formulæ of the higher mathematics have been avoided, yet without sacrificing any of the requirements of practical instruction; the arrangement of matter is such as to carry the reader along by easy steps to complete mastery of each subject; frequent examples for practice are given, to enable the reader to test his knowledge and make it a permanent possession; and the illustrations are selected with the greatest care to supplement and make clear the references in the text.

¶ The method adopted in the preparation of these volumes is that which the American School of Correspondence has developed and employed so successfully for many years. It is not an experiment, but has stood the severest of all tests—that of practical use—which has demonstrated it to be the best method yet devised for the education of the busy working man.

¶ For purposes of ready reference and timely information when needed, it is believed that this series of handbooks will be found to meet every requirement.

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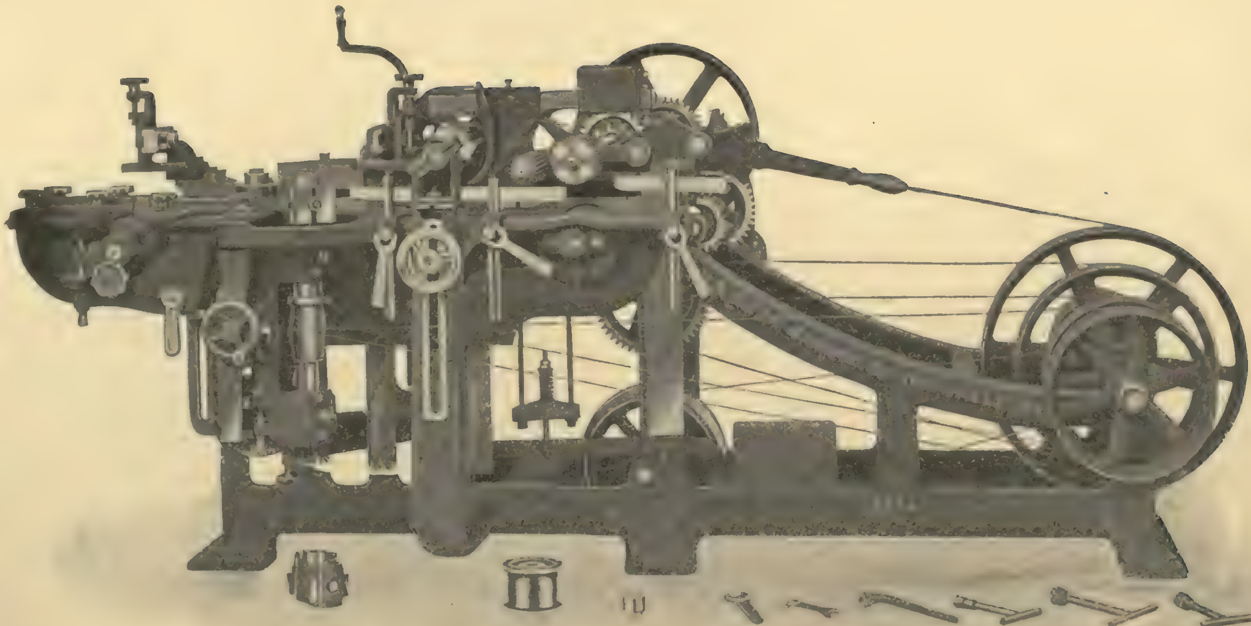


6-INCH MOULDING MACHINE.
H. B. Smith Machine Co.

PATTERN MAKING.

PART I.

PATTERN MAKING dates back to the time when the first article was made from molten metal for the use of man. The pattern must precede the making of its metal counterpart, and is therefore the first subject to be treated in the working of metal.

Qualifications of the Pattern Maker. The pattern maker is essentially a worker in wood, though, where many castings are to be made from the same pattern, the final or working pattern is made of metal. These metal patterns are very serviceable, and leave the sand more easily and cleanly than those made of wood. Metal patterns are always necessary when the work is of a delicate or very light character. In all such cases, however, the first pattern —from which the metal pattern is to be moulded—is made of wood, allowance being made for double shrinkage, and, when necessary, for double finish. The necessity for this will be clearly explained farther on.

The pattern maker should possess a practical knowledge of the properties of metals. First of all, he must understand the **shrinkage** of metals, that is to say, how much smaller the cold casting will be than the molten mass as it flows into the mould; he should know what the **strength** of the metal is; he should be familiar with the relative **rapidity of cooling,** so that internal stresses in the body of the completed casting may be avoided as much as possible; he also should know enough about the practical work of the moulder to decide upon the peculiarities of construction of the pattern for any given piece; and he must be sufficiently skilled as a draftsman to lay out, without the assistance of the designer, the drawings of the piece to be made. It is very true, however, that there are many good pattern makers who do not possess all of these qualifications.

The last-mentioned qualification is one of the most important. The drawings furnished the pattern maker are usually on a small scale.

In order to work to the best advantage, he must reproduce a part or all of them at full size, as working drawings. To do this in such a way that the lines and curves of the finished pattern shall be graceful and artistic in appearance, will require the same nicety and precision of workmanship that are demanded in the drafting room, and it is essential that the pattern maker have the same complete knowledge of the principles involved. To the extent, then, of being able, when necessary, to make a full-sized drawing of the article to be made, the pattern maker must be a draftsman.

In large establishments, where all the work comes to the pattern shop in the form of carefully executed drawings, the pattern maker is the means of putting the ideas of others into tangible shape. In smaller places, where no draftsman is employed, the pattern maker will be called upon to work out the designs for which he is to make his patterns, and he thus becomes the real designer.

Finally, the pattern maker is seldom required to make two patterns that are identically the same. His work, therefore, is varied, and he must be prepared to apply to the solution of new problems that arise such principles as he may already have learned.

Materials for Patterns. As patterns are subjected to more or less rough usage, and are alternately wet and dry, it follows that the ideal material is one whose hardness is such that it will withstand the wear and tear of handling and at the same time be impervious to the effects of moisture. Such material is to be found in the metals, but, as the cost of working these into the proper shape is considerable, some kind of **wood** is usually substituted.

Kind of Wood Used. If, then, wood is to be used, another qualification is to be added—namely, it should be easily worked. The best wood for the purpose is undoubtedly **white pine.** Care should be exercised in the inspection of the wood, to see that it is **clear, straight-grained,** and **free from knots.**

The straightness of the grain can be determined by the appearance of the sawn face. This should present an even roughness over the whole surface. The wood should be *seasoned* in the open air, but preferably sheltered by a roof, and should be piled so that the air will have free access to all parts of the plank. In the natural process of air drying, the moisture slowly works out to the surface and evaporates until the wood is dry or "seasoned." Such stock is firmer, stronger, more elastic, and less affected by heat and cold and by moisture and dryness, than kiln-dried lumber. In kiln drying, the outside surfaces and ends of the boards are dried more rapidly than the inside, producing strains that cause the wood to bend and warp while the pattern is in the process of construction. For this reason it is better to "build up" the larger pieces of a pattern by gluing together three or more (*never two*) pieces of thinner stock. When the patterns are of moderate size the stock to be glued may vary from $\frac{5}{8}$ inch to 1 inch or even $1\frac{1}{4}$ inches in thickness, in proportion to the size required. Stock of 2 inches thickness or over can seldom be found sufficiently seasoned; and, if forced by kiln-drying, it will be checked and strained to an extent that will render it useless for pattern work.

While pine is in general the ideal wood for pattern work, it is soft and weak, so that, if small and strong patterns are desired, a harder wood is usually employed. **Mahogany** is much used for this purpose. Like pine, it is not liable to warp, and, when straight-grained, it is worked with comparative ease. There are many varieties of this beautiful wood, varying greatly in firmness of texture. The soft bay wood, often sold as genuine mahogany, should be avoided for patterns, being but little harder than pine. **Cherry** is also extensively used, but is not so easily worked to a smooth surface as mahogany, and is more liable than the latter to warp and to be affected by moisture. **Black walnut, beech,** and **maple** are used to some extent. Black walnut is stronger than cherry, but, like beech and maple, is likely to warp.

It may be stated then, that, in the United States, white pine is the material commonly employed for pattern making. Lumber 1 inch, $1\frac{1}{4}$ inches, and $1\frac{1}{2}$ inches thick will be found convenient in the construction of such patterns as are most commonly called for It will be a great saving of time and labor, after the lumber has been carefully selected, to have it taken to the planing mill and dressed on two sides to the following thicknesses:

One-inch, dressed on two sides to	$\frac{7}{8}$ inch;
One and one-quarter-inch, dressed on two sides to	$1\frac{1}{8}$ inch;
One and one-half-inch, dressed on two sides to	$1\frac{3}{8}$ inch;

and, if such can be found well seasoned, a small quantity of two-inch, dressed to $1\frac{3}{4}$ inches.

In addition to these sizes there should be a moderate amount of 1-inch resawed and dressed to $\frac{3}{8}$ inch or to $\frac{5}{16}$ inch; and the same amount of $1\frac{1}{4}$-inch resawed and dressed to $\frac{1}{2}$ inch. The two last thicknesses are used for gluing and building up the rims of pulleys, gear wheels, and other light work where strength and durability are required.

Warping and Twisting of Wood. Observation shows that if one side of a board is kept damp and the other dried, the former will expand so that the plank, although originally straight, becomes curved as in Fig. 1. Or if one side of a board is exposed to the air, while the other is more or less protected, as in the stack of boards shown in Fig. 2, the exposed side of the upper board will give off its moisture more rapidly than the other side, and the board will warp or bend in the direction shown by the dotted lines. The second board will also "draw" and to some extent follow the first, being in turn followed by the third, and so on until the entire stack is warped and bent.

Fig. 1.

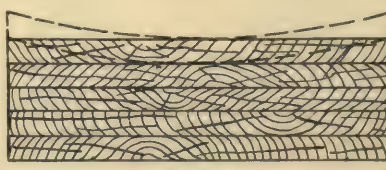


Fig. 2.

The same will be found true of a well-seasoned board if after being planed it is allowed to lie on its side on the work-bench. The upper side will give off its moisture more freely than is possible for the under side; the latter being protected and having its moisture retained by the bench. The lower side of the board is thus caused to expand, and the upper to contract, with the result that the board, although originally planed straight, becomes curved. For this reason all lumber, even if well-seasoned, should be so placed in racks, or on end, that the air may have free access to both sides of the planks; and newly planed boards, however dry and well seasoned, should never be stacked together, but so placed that both sides will be exposed alike.

This tendency to warp is explained to some extent by the porous nature of all woods, and their inclination to give off or to absorb moisture according to the condition of the surrounding atmosphere. As there is always more or less moisture in the air, and lumber of all kinds contains an amount of moisture which is ever changing according to the conditions of the surrounding atmosphere; this causes corresponding expansion or contraction of the wood.

Even under cover and in a dry place, wood has a tendency to warp on account of the greater shrinkage of the newer as compared with the older cells of the wood tissue or fiber in the side of the board nearest to the outside or sap wood of the tree. The inner side A of the board (Fig. 3) being closer to the heart wood, is older than the side B; its cells are firmer and more compact than those of B. As the board seasons, the newer and more open cells of the side B will shrink faster and to a greater extent than those of A, thus causing the board to draw or warp in the direction indicated by the dotted lines.

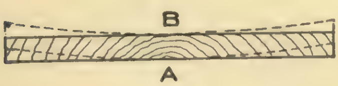


Fig. 3.


Fig. 4.

In gluing or building up stock for a pattern, this tendency may be corrected to some extent, by reversing the grain of the pieces that are to be glued, and placing two outsides (as B, Fig. 3) or two insides (as A, Fig. 3) together This is fully illustrated in Fig. 4.

In gluing very thin pieces together for the webs or centers of pulleys and for other purposes, it is often necessary to reverse the grain of the pieces, or to place the grain of *one piece at right angles to that of the other*, for the purpose of gaining greater strength and stiffness. In such cases, if only two thin pieces are used, the result, after they have been glued and dried, will be to some extent as shown in Fig. 5, the shrinkage and strain of the end grain crosswise of the board at *a*, being sufficient to bend the opposing thin board lengthwise of the grain at *b*, while on the side *cd*, the curve will be reversed for the same reason. *Whenever it is necessary to cross the grain of thin pieces for a pattern, three or more pieces should be used*, which will give satisfactory results if placed together as shown in Fig. 6.

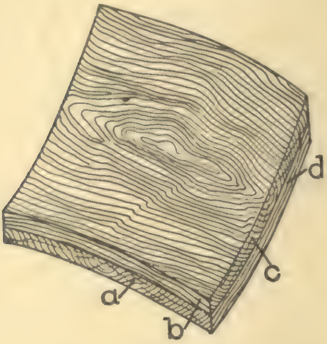


Fig. 5.

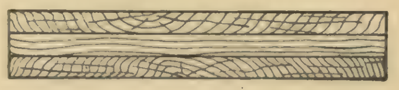


Fig. 6.

When thin circular disks of large size are to be glued up for patterns of any kind, the strongest, stiffest, and most satisfactory results will be obtained if the pieces are fitted and glued tangentially to the hub or other center or opening in the disk, as shown in Fig. 7. The grain of the wood must run lengthwise, and parallel to the longest side of each sector; and, after the pieces have been fitted together, a thin groove is cut in the edge of each, in which thin tongues of wood are inserted and glued, as illustrated in Fig. 8. Two disks are glued up, and one is turned over so as to reverse the grain of the sectors of one disk on that of the other, as shown by the dotted lines. The disks are then glued together, making a very rigid construction, and one which, owing to the continual change in the direction of the grain, will not warp.

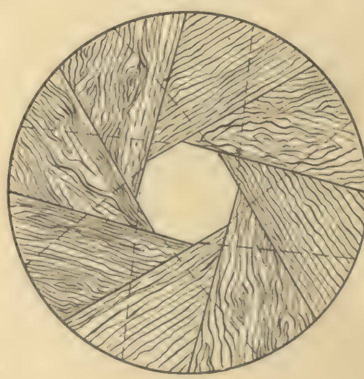


Fig. 7.

Fig. 8.

Should a wide and thin piece of a single thickness be required for a pattern, the board from which it is to be made should be ripped into strips of two, three, or four inches in width (according to the width of the required board), and the strips glued together again with each alternate strip reversed, as shown in Fig. 9. In this way the tendency to warp is to a great extent corrected, each narrow strip being inclined to warp in an opposite direction to that of its neighbor.

Fig. 9.

TOOLS.

While many of the tools used by the pattern maker are identical with those used by the carpenter and cabinet maker, yet the conditions that govern the construction of patterns for the molding of metals, together with the required accuracy in dimensions and the methods of construction used to guard against warping, distortion, and breaking, have very little in common with the workmanship and methods of the carpenter, the wood turner or the cabinet maker.

Following is a descriptive list of the more essential tools used in pattern making, accompanied with instructions in their use.

HAND SAWS.

Rip Saw and Crosscut Saw. Hand saws are of two kinds—**rip** and **crosscut.** The former, as the name indicates, is for cutting *with* the grain, or lengthwise of the board to be sawed. In Fig. 10 is illustrated a rip saw having $5\frac{1}{2}$ points to the inch, which will work rapidly and with ease in pine and other soft woods. If mahogany, cherry, or other hard wood is to be ripped, a six-point saw should be used. Rip saws should be filed with all the bevel on the back of the tooth, as shown at *b* in Fig. 10, the front or "throat" of the tooth being at right angles to, or "square" with, the tooth edge of the blade, as at *a* in the same figure. The position of the line *cd*, whether perpendicular or slanting, is called the "hook" or "pitch" of the tooth.

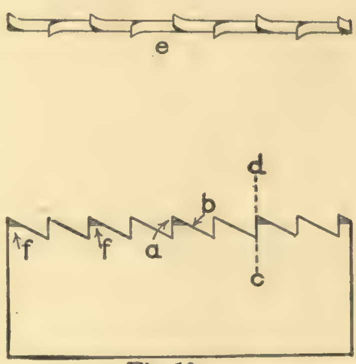


Fig. 10.

Rip saws should be filed square across; that is, the file should be held horizontal and at right angles to the side of the blade, always filing each alternate tooth from the opposite side of the saw; this, if done by beginning at the heel and working the file toward the point of the blade, will give a very slight bevel to the back edge of the tooth, causing it to cut cleaner and with less set than if filed otherwise.

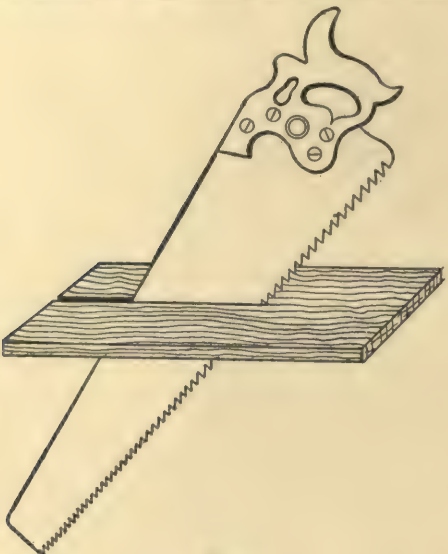


Fig. 11.

Rip saws require very little set for use in dry, well-seasoned lumber, such as is always used in pattern making. The teeth should be "set," or bent, only at the points, as shown at *e* and *f* in Fig. 10; and in no case should the set exceed more than half the depth of the tooth.

When the points only are set, the saw will work more freely, and the blade of the saw will not be "sprung," or bent, in setting In using a rip saw, the front or cutting edge of the saw blade should be held at an angle of about 45° to the board, as shown in Fig. 11. This brings the back of the tooth nearly at right angles to the fibres of the wood, and insures a shearing cut. For fine work and well-seasoned material, hand saws may be bought ground so thin on the back as to require no set. Such tools work very smoothly and easily, cutting away less wood and doing better work than saws that have been set.

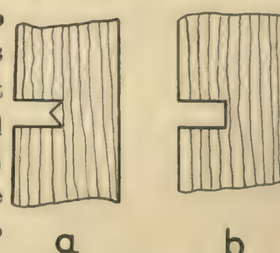


Fig. 12.

The crosscut saw really severs or cuts the fibres of the wood twice, as shown at *a* in Fig. 12, the intervening projections being loosened and carried out as dust by the thrust of the saw, producing a nearly straight-bottomed kerf, as shown at *b* (Fig. 12).

A crosscut saw for ordinary work should have five or six points to the inch; but for fine work ten or twelve points would be better, especially for dry woods, either soft or hard.

A section of a 6-point crosscut saw is shown in Fig. 13, and one of an $13\frac{1}{2}$-point in Fig. 14.

In considering rip saws we find that the rake or bevel is all on the back of the tooth. In crosscut saws the rake is on the side of the tooth, as shown at *a* (Fig. 13.) In ripping, the point of the tooth acts as a chisel, cutting off the fibers of the wood, each tooth chiseling off a shaving as it passes through the board; but in crosscutting, the side of the tooth does the cutting, and therefore must have its bevel on the side.

Fig. 13.

In Fig. 13 the bevel or **fleam** of the tooth is about 45°, and, as shown, there is no hook or pitch, the angle being the same on both the front and back of the tooth. This form of tooth works well in wet or in very soft wood; but for wood that is well seasoned, and for all the harder and firmer woods, the pitch of the front of the tooth should be at an angle of about 60° to the tooth edge of the blade, as shown in Fig. 15, and at *b* in Fig. 16. The amount of pitch in the teeth of a saw may be varied as demanded for different purposes or for different woods, but in all cases should be such as

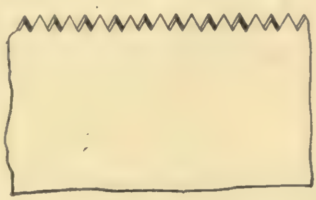


Fig. 14.

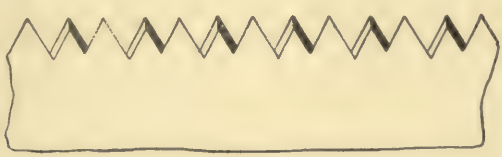


Fig. 15.

to loosen and carry out the intervening wood. Otherwise this would have to be rasped or filed out by the continued action of the saw.

The fleam of the side of the crosscut saw tooth is very important. When filing, the file should be held horizontally and at an angle of about 45° to the side of the saw, lengthwise of the blade, as illustrated in Fig. 16; and each alternate tooth must be filed from the opposite side of the blade, beginning at the heel and filing toward the point of the saw.

The objection is often raised by saw filers, that in filing from the handle end of the saw toward the point, a feather edge is made by the file and turned backward on the point of the tooth. The first thrust of the saw through the board, however, will remove this feather edge entirely; whereas, if the filing be done from the point of the saw toward the handle, it is necessary to file the teeth bent toward the operator, which causes the saw to vibrate, or "chatter;" and this not only renders good, even filing impossible, but breaks the teeth of the file.

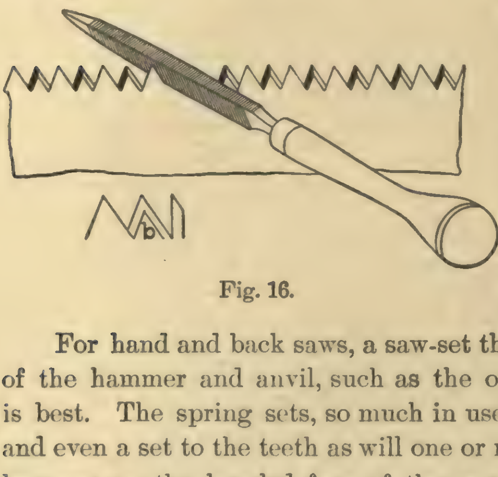


Fig. 16.

For hand and back saws, a saw-set that acts on the principle of the hammer and anvil, such as the one illustrated in Fig. 17, is best. The spring sets, so much in use, will not give so regular and even a set to the teeth as will one or more light blows with the hammer on the beveled face of the anvil. By this method the tooth is not bent or sprung beyond the position in which it is intended to remain, and the blade of the saw is not bent or affected by the stroke of the hammer on the point of the tooth. A saw-set of the kind illustrated in Fig. 17 can be adjusted to set the points of the teeth to any depth desired; and, even if repeated light blows are given, the tooth cannot be bent beyond the required distance. The blow may be struck on *a* with a light mallet; or it may be struck from below with the operator's foot on a treadle connected with *e*, leaving both hands free to hold and to guide the saw.

In setting a saw, it is always better to use two or three light blows on a tooth than to try to do the work with one heavy blow; and this is especially the case if the saw is hard, as all good and well-tempered saws should be.

The **back saw** illustrated in Fig. 18 is used as a bench saw for light or fine work, and for fitting and dovetailing. Saws of this type are made from 8 to 14 inches in length, the 10- and 12-inch being convenient sizes for general work. As the metal back holds and stiffens the saw, a thin blade should always be selected; and the methods of filing, jointing and setting are the same as already described for hand saws. At least two back saws will be found necessary, one filed for crosscutting, and the other filed as a rip saw for cutting *with* the grain of the wood, as in the cutting of tenons and dovetails.

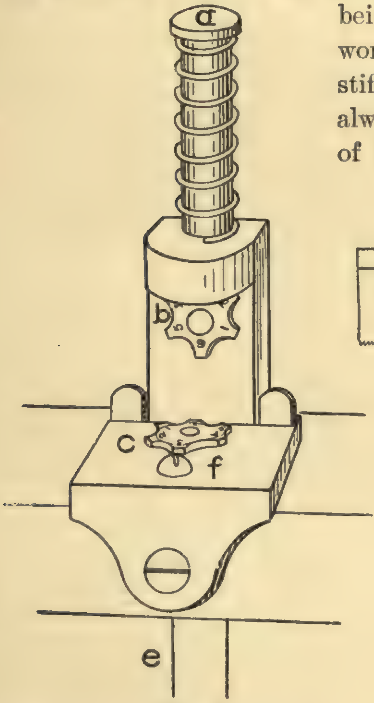


Fig. 17.

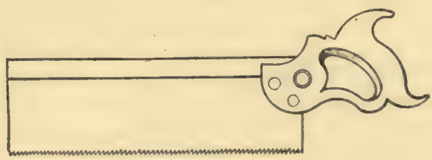


Fig. 18.

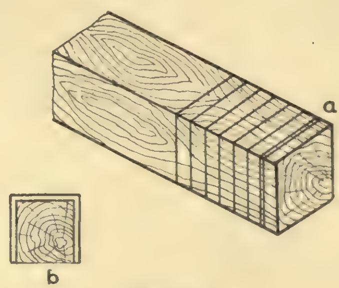


Fig. 19.

EXERCISE.

While for those who have had experience in carpentry the following exercise in the use of the back saw may not be necessary, it is recommended to all beginners who wish to acquire skill in the use of this important tool.

Take any block of wood from 12 inches to 16 inches long, about 2 inches wide, and about 1¾ inches in thickness. With try-square and a sharp-pointed pocketknife, lay it out as illustrated in Fig. 19, on the upper, front, and back sides of the block. The knife-cuts must be at least $\frac{1}{32}$ inch deep, and about ¼ inch distant from each other. Next proceed to saw up the block into thin sections, sawing each time so that the saw kerf will be just outside of, but close to the knife line, as indicated at *a*.

The saw-cut through the block should be true to each of the three lines; and while the saw passes along one side of the line, its teeth should not scratch the opposite side of the knife-cut, but should leave a smooth, clean angle of the knife-cut on the block, as shown at *b* in Fig. 19, while at the same time it should be so close to the line as to leave no wood to be smoothed off with plane or chisel.

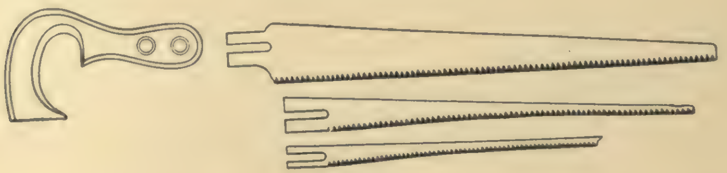


Fig. 20.

A few hours' thorough and careful practice of this exercise will enable any one to use the saw successfully.

Compass Saw. As the work of the compass saw, illustrated in Fig. 20, will be both *with* and *across* the grain of the wood, the best form of tooth will be that shown in Fig. 21, having more pitch, and slightly less bevel, than the crosscut saw. A crosscut saw will rip better than a rip saw will crosscut; hence the shape of tooth should be between the two. Compass saws are ground very thin on the back of the blade, but in order to turn easily they should be set the same as hand saws. And here we wish to impress on the beginner the necessity of keeping his saw and indeed all other cutting tools—perfectly sharp and in good working condition at all times. A sharp saw will work faster, and will always do smoother and better work with less set and with less expenditure of power, than a dull one. Even to saw well is an art, which cannot be gained through the use of dull, imperfectly set, and poorly kept tools. To file well will require from the beginner close attention, a study of the subject, and careful practice, all of which

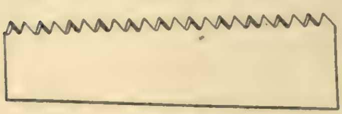


Fig. 21.

can be given by any one possessing ordinary mechanical ability. If the filing is done slowly at first, care being taken to hold the file at the same angle for all the teeth, a little faithful practice will always bring success.

PLANES.

The Iron Plane. The modern iron plane, illustrated in Fig. 22, can now be bought in a great variety of sizes and styles. These planes, with their true and unchanging faces, and their simple appliances for setting and adjusting the cutter (or **plane-iron**) to the face of the plane and to the required thickness of shavings, are greatly to be preferred to the old-style wooden planes.

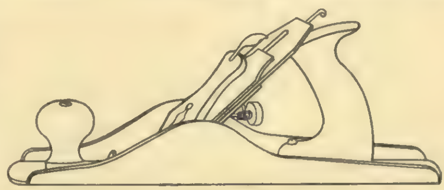


Fig. 22.

The general construction of the iron plane will be readily understood from Fig. 23, one side of the plane being removed to show the arrangement of the parts; *a* is the cutter, or plane-iron, which is made of the best cast steel and of equal thickness throughout. In all new planes this part will be found ground and sharpened for immediate use.

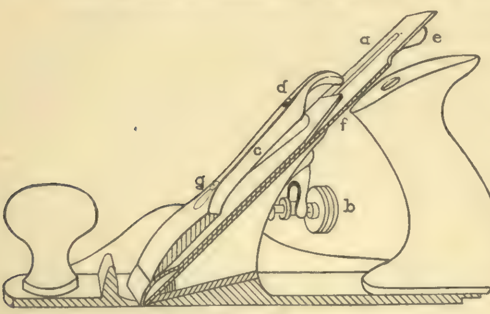


Fig. 23.

The cap-iron *f* (Fig. 23) is fastened to the plane-iron,

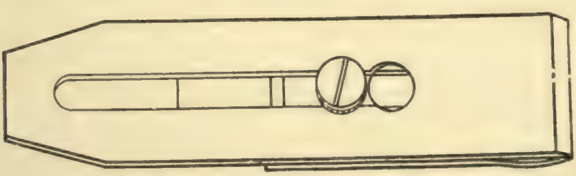


Fig. 24.

by an adjusting screw, as shown in Fig. 24. For whetting or grinding the cutting edge, it is not necessary to remove the cap-iron, but only to loosen the connecting screw and to slide the cap back to the extreme end of the slot in the plane-iron, tightening it there by a turn of the screw. The cap-iron will then serve as a convenient handle or rest in whetting or in grinding.

The iron lever *c* (Fig. 23) is held in place below its center by the screw *g*, which acts as a fulcrum, and the lever is readily clamped down upon the irons by the use of the cam-piece *d*. When this cam is turned upward it ceases to bear upon the irons. The lever *c* may then be removed from its place, and the irons released, without turning or changing the adjustment of the screw *g*, as the lever and irons are properly slotted for this purpose.

Should the pressure required for the best working of the plane-iron need changing, it can easily be obtained by tightening or loosening the screw *g*.

When the plane-iron is secured in its place, the use of the brass thumb-screw *b* will *draw* or *drive* the plane-iron; and thus the thickness of the shaving to be taken from the work can be regulated with perfect accuracy. By the use of the lever *e*, located under the plane-iron, and working sidewise, the cutting edge can easily be brought into position exactly parallel with the face of the plane, should any variation exist when the iron is clamped down. To ascertain this, hold the plane up, and look down over its face; the greater projection, if there be any, of one or the other of the corners of the iron, can readily be seen.

The cap-iron *f*, which is not sharp, is *not*, as is often supposed, used for the purpose of strengthening or stiffening the cutting iron, but as a chip-break to prevent the cutting edge of the plane-iron from chipping, tearing, and breaking the grain of the wood below the surface when the grain turns and twists, or when it is knotty and crooked. In such cases the tendency of the plane-iron is to split and tear out the fibres of the wood in front of the cutting edge. To avoid this, the cap-iron is screwed on with its dull edge quite close to the cutting edge, so as to bend and break off the fibres or the shavings before the split gets fairly started below the surface.

The cutting edge of the plane-iron is said to have *lead* in proportion to the distance it is placed in advance of the dull edge of the cap-iron. The depth of the splits, or the roughness of the cross-grained surface, will be just equal to the lead of the cutting edge. For soft, straight-grained wood, the lead may be $\frac{1}{32}$ inch or even more, but this must be reduced in proportion as the wood is curly, cross-grained, or knotty.

The grinding, or the whetting, must always be done on the *bevel* side only of the plane-iron, the upper side being kept as flat and as smooth as possible to secure easy working.

All plane-irons should be ground slightly rounding to the extent of the thickness of a thin shaving. This rounding of the cutting edge should be the true arc of a circle throughout the entire length of the cutting edge, and not simply a rounding-off of the corners as is sometimes directed. Rounding the edge to the extent of the thickness of a shaving will prevent the plane-iron from grooving into, or plowing out a wide groove in, the surface that is being worked, and will also assist greatly in working the edges of the piece to right angles, or square with the face side. To do this it is not necessary, should one corner of the edge be higher than the other, to tilt the plane on the high edge, but, while holding it flat and firm on the surface of the edge being planed, push the plane sidewise towards the highest corner in order to reduce that corner. This will readily be understood when we remember that the cutting edge of the iron is rounding. If the plane is held so that the middle of the plane-iron will do the cutting, the shaving planed will be of the same thickness on both edges; but if the plane is pushed over to one side, either to the right or to the left, the shaving will be feather-edged, or thick on one edge and thin on the other, thus reducing the higher corner of the edge of the piece.

When the plane is to be used, the beginner should first carefully adjust it to the thickness of shaving required, by holding it up and looking down over the face of the plane, when the projection of the plane-iron can readily be seen, and then by testing on the piece to be planed.

The operator's position should be one of perfect ease, standing well back of the piece to be planed, and pushing the plane to arm's length *from* (not alongside of) the operator, taking long and continued shavings from the board. When starting the shaving at the end of the board, care should be taken to hold the forward end of the plane down firmly, or the act of pushing it forward will cause that end to tilt up and the plane-iron to chatter on the surface as it begins to cut the shaving. This is owing to the fact that nearly two-thirds of the plane overhangs the end of the board, requiring firm pressure on the forward end to balance it while the stroke is being started.

To insure smooth work, care must be taken to plane *with the grain* of the wood, and not *against* the ends of the fibres as they lie in the surface of the board. Should the fibres tear out and the surface become rough, reverse the ends of the boards so as to cut the shaving in the opposite direction, and note the difference in the effect on the planed surface.

Fig. 25.

Of iron planes, the most important is the No. 5 **jack plane,** 14 inches long, and having a cutter 2 inches in width. This plane is illustrated in Fig. 25.

When the pattern lumber has first been roughly planed in a planing mill, this No. 5 plane almost exclusively can be used for planing and pattern making. In making or in "truing up" very large surfaces, however, or in making long glue joints, the No. 7 **jointer plane,** 22 inches long and having a cutter $2\frac{5}{8}$ inches wide, will be found necessary. This plane is shown in Fig. 22, and differs from the jack plane only in its length and in its extra width of face.

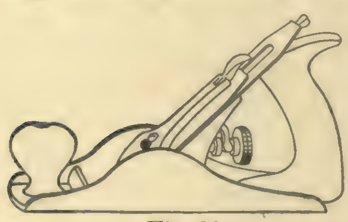
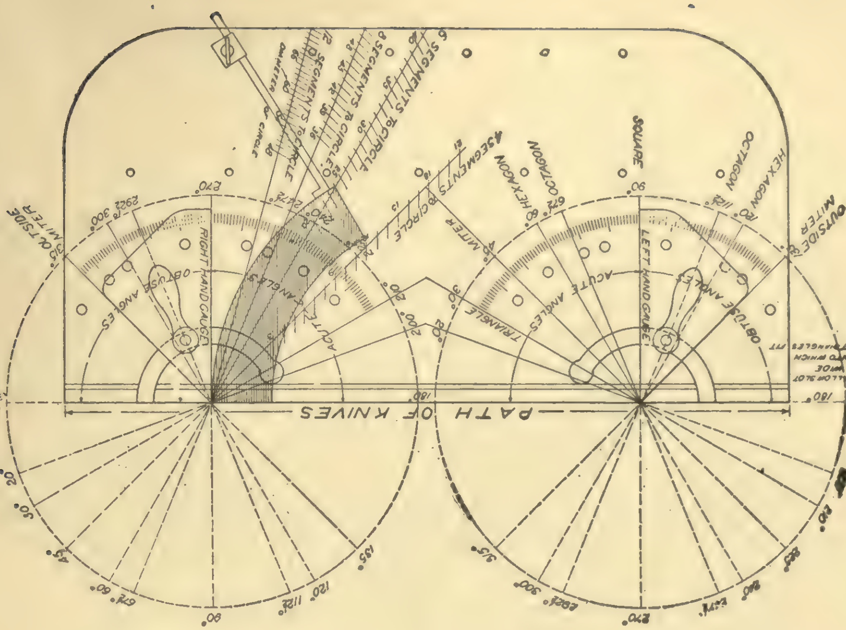
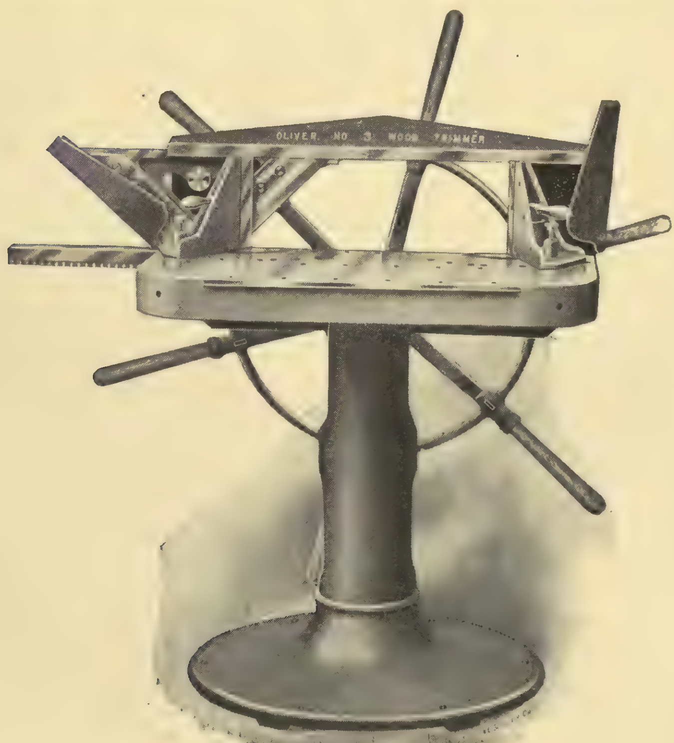


Fig. 26.

For mahogany or other hard wood, the No. 4 **smooth plane,** illustrated in Fig. 26, will be found very useful. This plane is made in several sizes. The No. 4, which is 9 inches long and has a 2-inch cutter, is the best size for general use.

Next in importance to the three planes already mentioned, is the **block plane,** illustrated in Fig. 27. The No. 19, which is 7 inches long and has a cutter $1\frac{3}{4}$ inches wide, is the most desirable for the pattern maker's use. It has an adjustable throat, as well as the screw and lateral lever adjustments of the other planes. This





UNIVERSAL TRIMMER, SHOWING GRADUATIONS.
Oliver Machinery Company.

plane has the advantage of being so constructed as to be held easily in one hand. Owing to the low angle at which the cutter is placed it works more smoothly and easily on end wood and on miters than any other plane.

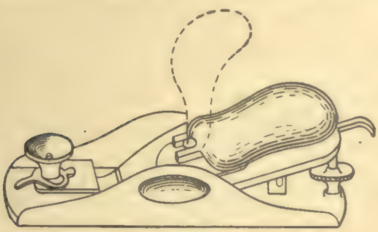


Fig. 27.

In cases where lumber must be dressed from the rough, without being first roughly dressed in a planing mill, the No. 40 **scrub plane,** illustrated in Fig. 28, will be almost indispensable. It is 9½ inches long, and has a cutter 1¼ inches wide. The cutter is a single iron, and is ground and sharpened very rounding on the cutting edge, as shown in Fig. 28, to allow of cutting a very thick shaving without grooving at the edges. This plane works rapidly and easily, preparing the rough-sawn surfaces of planks for the finishing planes.

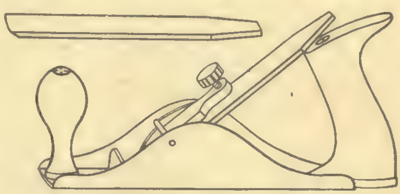


Fig. 28.

For truing and smoothing circular arcs and curves of all kinds, either convex or concave, there is no tool that equals the **circular plane,** illustrated in Fig. 29. This plane has a flexible steel face

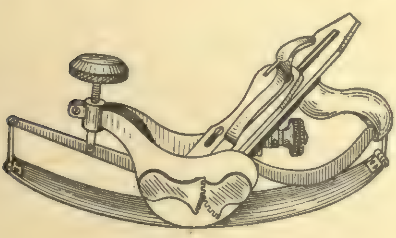


Fig. 29.

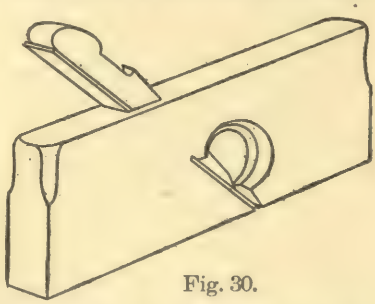


Fig. 30.

which can easily be shaped to any required arc or curve by turning the knob on the front of the plane.

The Rabbet Plane. Among the special planes used by the pattern maker, the rabbet plane, illustrated in Fig. 30, is the most important. The face of this plane is always flat and at right angles to the sides. It is used in working out square angles and corners, or *laps* as they are called in carpentry, and also for working lap joints, as shown in Fig. 31.

Fig. 31.

The skew-iron rabbet plane, in which the cutting edge of the plane-iron is set diagonally across the face of the plane, works much more smoothly and easily than one in which the iron is set at right angles to the side of the plane. The improved rabbet

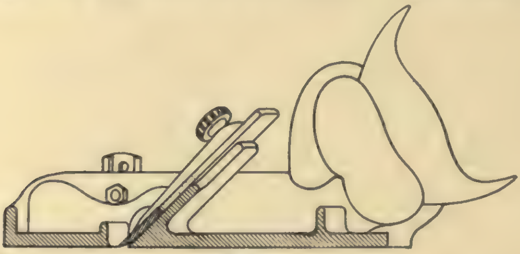


Fig. 32.

plane shown in Fig. 32 is fitted with depth gauge, and also with a spur cutter, both of which are often of great convenience to the workman.

Rabbet planes are made in sizes ranging from ½ inch to 1½ inches in width. The 1-inch and 1¼-inch are convenient sizes for general work.

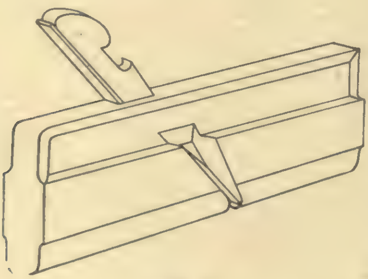


Fig. 33.

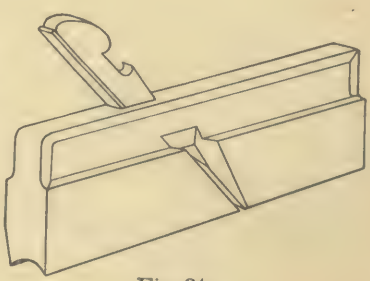


Fig. 34.

Round and Hollow Planes. These planes are illustrated in Figs. 33 and 34. They are made of different curvatures, and a set of assorted sizes, especially the *rounds*, are almost indispensable to the pattern maker for finishing semicircular core boxes, for making fillets, and for working out curves of every description, both concave and convex.

The Core-Box Plane. The core-box plane, shown in Fig. 35, while not indispensable, will be found to be a very rapid working and useful tool for making semicircular core boxes up to 2½ inches in diameter. By using the extension sides, one of which is shown in the illustration, and two pairs of which are always furnished, this tool will work accurately a concave semicircle up to 10 inches in diameter.

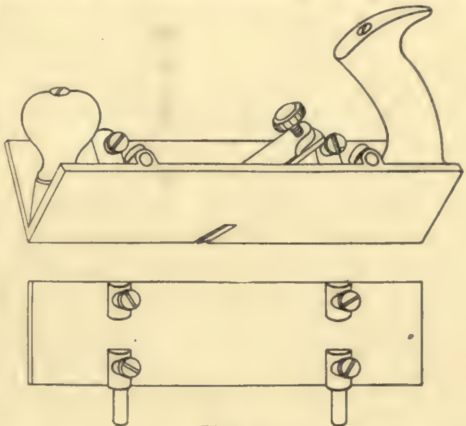


Fig. 35.

The core-box plane is constructed upon the principle that if the sides of a right angle lie upon the extremities of a diameter of a circle, the vertex of the right angle will lie upon the circumference of the circle. This is illustrated in Fig. 36, from which it will be seen that if the block of wood has been worked to a perfect semicircle, and the edges of the blades of a try-square or right-angled triangle touch the semicircular curve at its extremities,

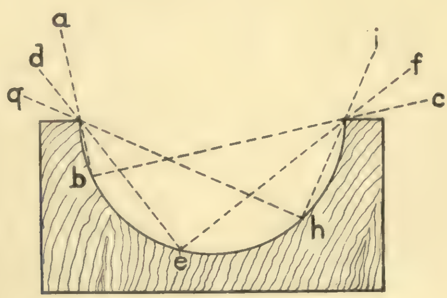


Fig. 36.

the right angle or corner will touch the arc at some point, as *b*, *e* or *h*, the angles *abc*, *def*, and *ghi* all being right angles.

To this kind of plane the objection is often made that it abrades and wears off the corners of the semicircle as it is being worked out. This, however, can be practically avoided if the following instructions are followed:

Carefully lay out the block from which the core box is to be worked, from a center line on the face of the block, describing on each end of the block a semicircle of the required radius; connect the extremes of the two end arcs by straight lines on the face of the block, as shown in Fig. 37. Two very thin strips of hard wood are tacked along these lines, just outside of the wood to be cut away, as shown at *a* and at *b* in Fig. 38. These strips form rests for the sides of the plane while the heavier part of the work is being done. After working out the semicircle as far as the strips will allow, as shown by the dotted arc *acb*, the strips are removed, when the work can be finished without materially affecting the corners at *a* and *b*.

When making the finishing cuts with this plane, care must be taken to adjust the cutter centrally, *i. e.*, so that it will cut equally to both right and left; otherwise the work will not be correct. If, however, the work has been done with care, the finishing may be completed with coarse, and lastly with fine, sandpaper held on a cylindrical block of radius slightly less than that of the required core box.

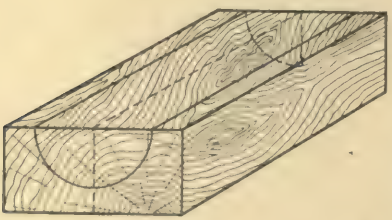


Fig. 37.

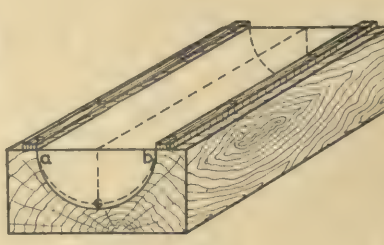


Fig. 38.

The Router Plane. This tool will be found very convenient for smoothing out sunk panels, for letting in rapping and lifting plates, and for all depressions below the general surface of the pattern. It will plane the bottoms of recesses to a uniform depth from the surface of the work, and will work into angles and corners that otherwise could be reached only by the use of the paring chisel. It is illustrated in Fig. 39.

The Spoke-Shave. The spoke-shave is used by the pattern maker for shaping and rounding out small curves either convex or concave, which cannot be reached with the circular plane. It can be found in a great variety of styles, either in metal, as shown in Fig. 40, or in wood. The all-wood boxwood spoke shave illustrated in Fig. 41, without brass facing or screw adjustment, is to be preferred to all others for the pattern maker's use, especially for working pine or other soft wood.

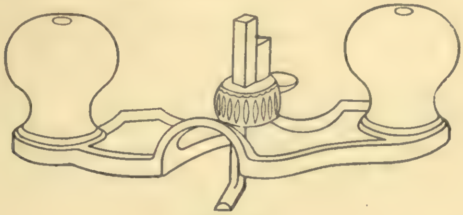


Fig. 39.

CHISELS AND GOUGES.

The chisel enters so largely into the work of the pattern maker in paring and shaping patterns that the quality of the tool should

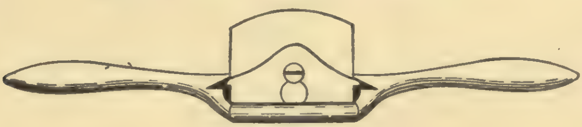


Fig. 40.

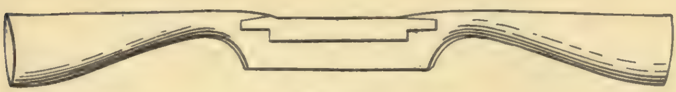


Fig. 41.

be of the best. While carpenters' chisels are made in several styles, they may be divided into two general classes, **socket-handled chisels,** and **firmer** or **paring chisels.** The former are illustrated

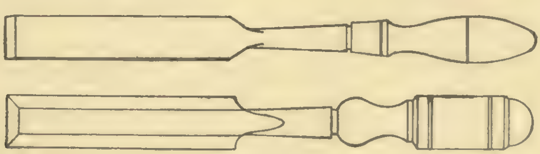


Fig. 42.

in Fig. 42, and are used for framing, and for very heavy work of all kinds in which the use of a mallet is necessary. The common firmer or paring chisels, two styles of which are shown in Fig. 43, are the best all-round chisels for pattern work. Being lighter and thinner than the others, they are better adapted to the light work on which they are used; moreover, when used with care, they will answer every desired purpose, even for heavy work or with a mallet.

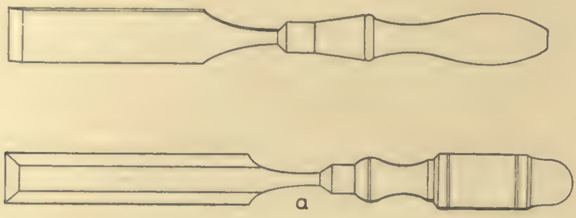


Fig. 43.

The beveled-edge chisel shown at *a*, Fig. 43, is greatly to be preferred. It is lighter than the other kind illustrated, and the square angle being removed, the workman is enabled to reach into angles and under projections difficult to reach with a

Fig. 44.

Fig. 45.

square-edged tool. A set varying in width from $\frac{1}{8}$ inch to $\frac{5}{8}$ inch by eighths, and from $\frac{3}{4}$ inch to $1\frac{1}{2}$ inches by quarters, nine chisels in all, will be found useful.

The paring gouges used in pattern making are ground or beveled on the inside, as shown in Fig. 44. These gouges are made in **regular, middle,** and **flat** sweeps. They are indispensable for working out core boxes and other curves.

In selecting a set of paring gouges, they should be not only of assorted sizes, but of different sweeps, so as to work out semicircles and curves of different radii

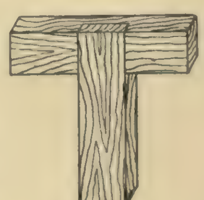


Fig. 47.

The common firmer gouge, illustrated in Fig. 45, is a useful tool for rough or heavy work, but in general its use can be dispensed with in pattern making.

The manner in which the chisel is used is so obvious and simple that any instruction in that direction would seem unneces-

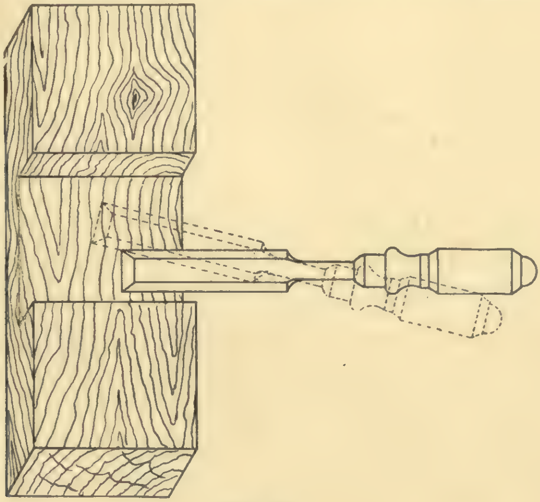


Fig. 46.

sary. We shall only say in a general way that in using a chisel on a flat surface or in a recess it should always be held with the flat or back of the chisel against the work; and, whenever possible, it should not be pushed straight forward or straight through an opening, especially when paring across the grain of the wood, but should be moved laterally at the same time that it is pushed forward, as indicated by the dotted lines in Fig. 46. This insures a shearing cut, which, with care, even when the material is cross-grained, will produce a smooth and even surface.

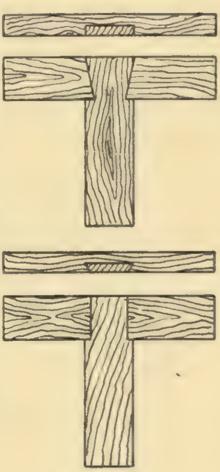


Fig. 48.

As an exercise for acquiring the free use of the paring chisel, there is nothing better for the beginner than the simple half-lap joint shown in Fig. 47.

The shoulders or the ends of the openings must be cut with a back saw. The opening is then cut out and the shoulders smoothed with a wide chisel, and a perfect fit obtained by continued trials.

The two dove-tail joints shown in Fig. 48 may be attempted, after having succeeded with the half-lap; and these exercises should be continued by the student until such control of the chisel is attained that this and similar work can be done with ease and certainty. For laying out work of this kind the blade of a pocketknife or bench knife should always be used. This gives a clean, sharp-cut angle for the meeting sides of the joints, which cannot be obtained if a scratch-awl is used. The awl tears and breaks the fibres of the wood, producing a rough, ragged angle, which, on fitting, cannot produce a smooth and close piece of work. A pencil is equally objectionable because of the indefinite dimensions given by its use.

An assortment of four to nine carver's gouges, **front bent** as

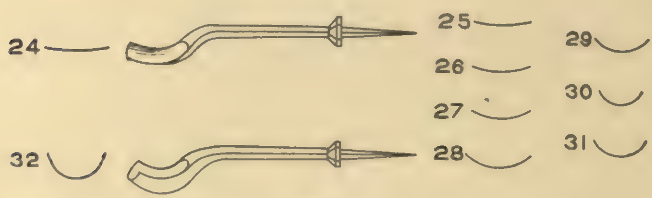


Fig. 49.

shown in Fig. 49, will be found necessary for working out short, deep curves, and in places where a straight gouge cannot be used, as in the core boxes for a globe valve, shown in Figs. 222, 223, 227, 228, and similar work.

The full set consists of *nine* tools, the curves of which are numbered from 24 to 32. The two extremes, Nos. 24 and 32, are shown in Fig. 49, and also the shapes of the curves of the seven intermediates, Nos. 25 to 31 inclusive.

If desired, to save expense, each alternate tool might be omitted from the set, only the odd numbers 25, 27, 29 and 31 being selected. For ordinary work these will be found sufficient.

SQUARES.

The best try-squares are now made with graduated blades, Fig. 50, and from two inches to twelve inches in length of blade. Several sizes will be found necessary, as in many cases the blade must be short to admit of its application in pattern work.

The adjustable try-square, illustrated in Fig. 51, is not expensive, and will be found to fill the requirements of several small squares. It is made in two sizes, with graduated blades four inches and six inches in length respectively. The blade of

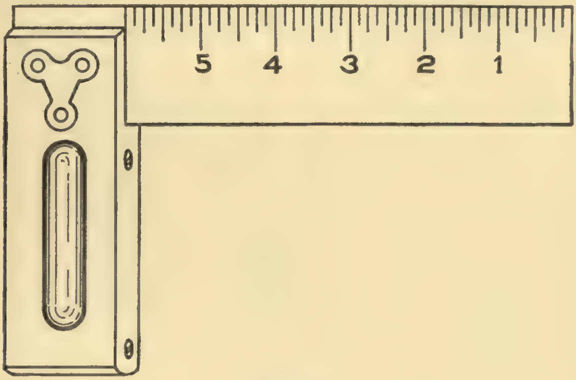


Fig. 50.

this square can be firmly secured in its seat at any point. When the blade is carried entirely to the front of the handle, it is like an ordinary try-square; and the moving of the blade makes the square equally perfect down to one-quarter-inch length of blade, or even less.

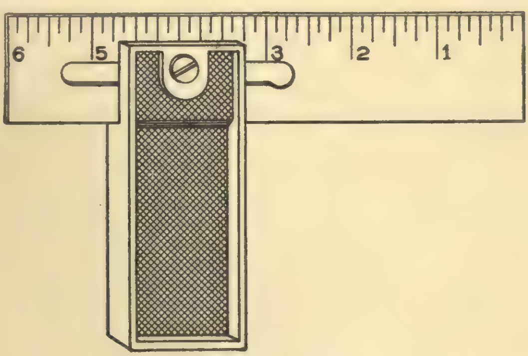


Fig. 51.

With one adjustable square of this kind, six inches in length, only one 8-inch or one 10-inch ordinary square will be found necessary.

A still more convenient, but slightly more expensive, form of adjustable try-square is shown in Fig. 52. It differs from that shown in Fig. 51, in being self-contained, no screw-driver being necessary for moving the blade or securing it in position, and also because the blade can be removed entirely, and an extra blade,

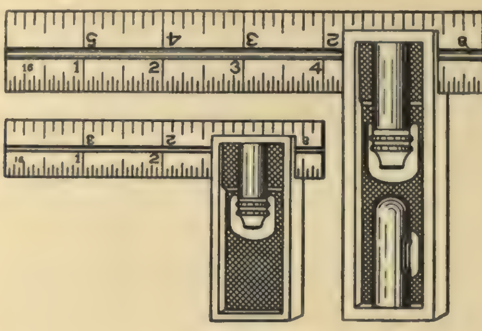


Fig. 52.

shown in Fig. 53, substituted. The ends of this second blade give both the hexagon and octagon angles, which is a matter of great convenience to the pattern maker. Fig. 53 shows the hexagon end of the blade applied. Reverse the blade and the octagon end will be in position for use.

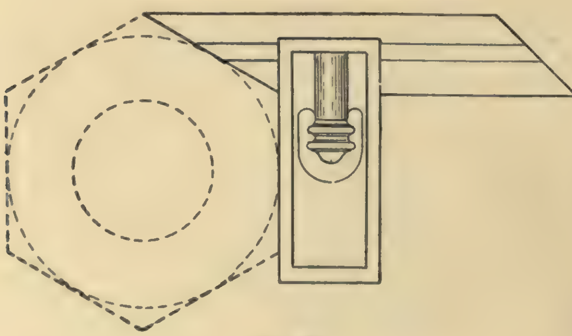


Fig. 53.

To the above try-squares there should be added a carpenter's steel square 24 inches × 18 inches, for use in laying out and squaring up large stock and large patterns.

BEVELS.

The bevel illustrated in Fig. 54, with the clamping screw in the end of the handle, is the most accurate and the most easily adjusted style of this indispensable tool. The blades are made from 6 to 12 inches in length, and have a slot in one end, which admits of that end being shortened to meet the requirements of work.

The small **Universal bevel,** illustrated in Fig. 55, like the adjustable try-square, is not an expensive tool, and will be found generally useful, especially in working the draft on patterns, and in turning the parts of patterns on the wood lathe which cannot be reached with an ordinary bevel. The *set-off* in the blade increases its capacity and usefulness, so that any angle, however slight, can be obtained.

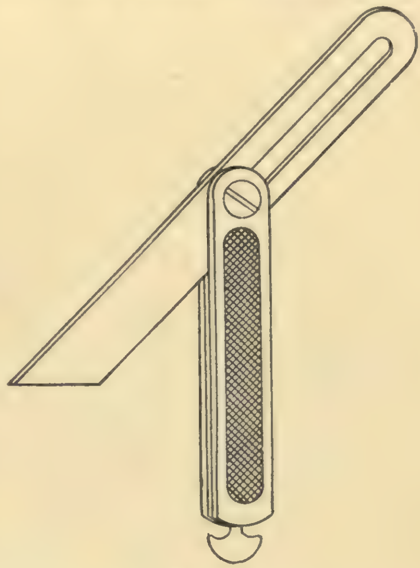


Fig. 54.

One 3-inch *Universal*, and one 8-inch or 10-inch ordinary

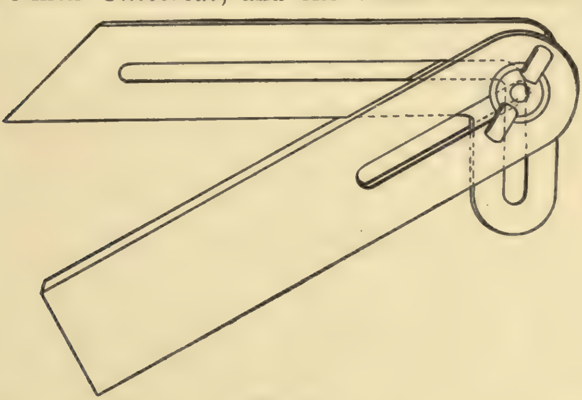


Fig. 55.

bevel, will meet all the requirements of the pattern maker for the beveled edges and surfaces and the draft of pattern work.

MARKING GAGES.

The marking gage is used for drawing a line at a given distance from, and parallel to, the already trued and jointed surface or edge of a board or piece of wood that is being marked to dimensions. There are many forms of this tool, but in the "Improved

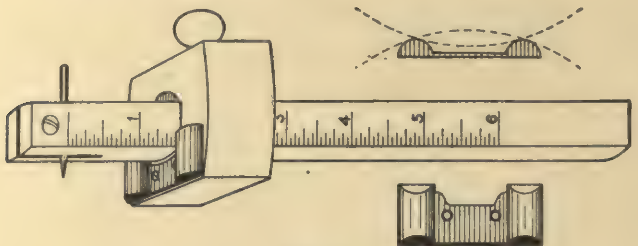


Fig. 56.

Marking Gage," illustrated in Fig. 56, the head is reversible. The flat side of the head is used for ordinary straight work, while the reverse side, having the brass face with two projecting ribs,

Fig. 57.

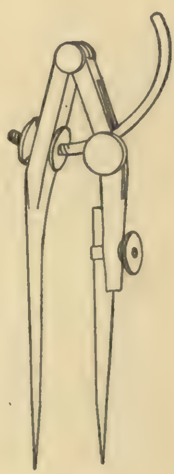


Fig. 58.

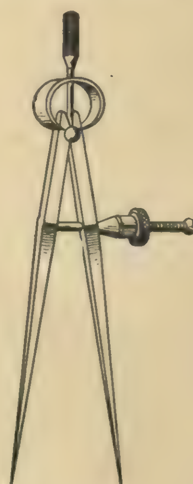


Fig. 59.

enables the operator to run a gage line with perfect steadiness and accuracy around curves of any radius, either convex or concave —a feature much to be desired in a pattern-maker's gage.

DIVIDERS AND TRAMMELS.

The ordinary wood-worker's dividers can be bought in many forms, the most common being the **screw-adjusting wing dividers,** shown in Fig. 57. This form is reliable, and is easily adjusted to the required distance between points. Moreover, when clamped by the thumb-screw, it is not liable to be altered by a slight blow in handling.

Another and improved form is shown in Fig. 58, one leg of which is removable so that a pencil can be inserted. This will be found very convenient for marking and laying out work.

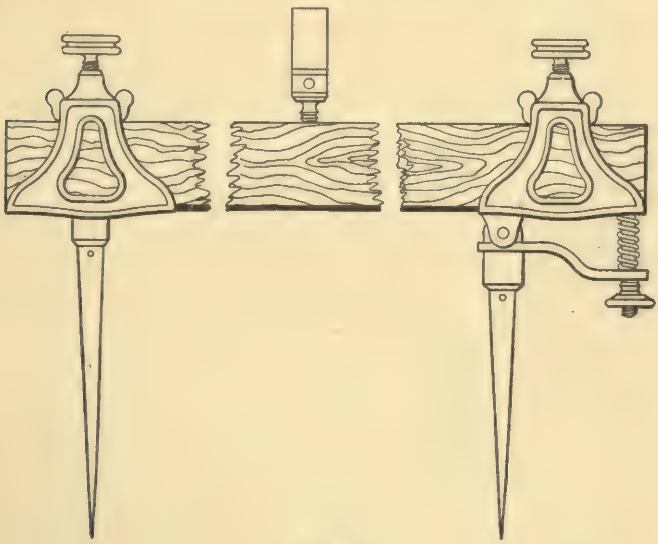


Fig. 60.

For spacing the teeth of gear wheels, and for other work in which great accuracy is required, a pair of 2½-inch or 3-inch dividers, such as are shown in Fig. 59, will be found necessary.

The **trammel** is used when the distance between the points to be reached is too great for the ordinary dividers. The trammel points are clamped to a beam of sufficient length to enable them to be set to the required distance apart. They may be bought with one adjustable point, as illustrated in Fig. 60; or without the screw adjustment, as in Fig. 61. The points are removable for the insertion of a pencil socket and pencil when needed.

For very accurate work, an excellent tool of this kind is illustrated in Fig. 62. The beams furnished are 4 inches and 13 inches in length. By the use of the cone center, shown at V, which may be substituted for the regular point, the tool can be used for scribing a line around any hole already bored—which is sometimes a matter of great convenience. The complete set includes the pen, pencil, straight and bent points, and the cone center, as shown in the cut.

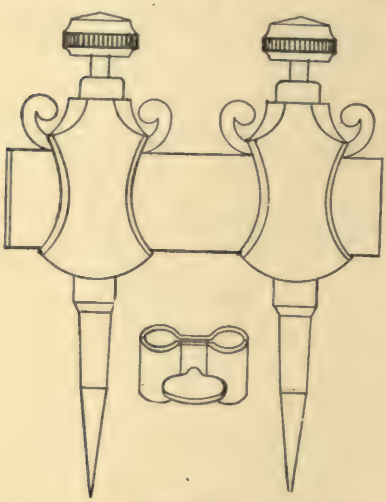


Fig. 61.

CALIPERS.

Calipers, like dividers, are made in many different forms, with and without screw adjustment. Fig. 63 illustrates the screw-

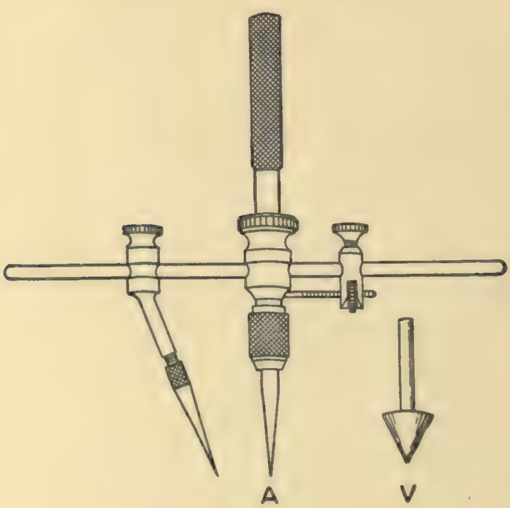


Fig. 62.

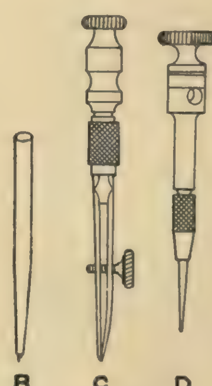


Fig. 62A.

adjusting wing calipers for outside measurements; and Fig. 64 the firm-joint outside calipers, used for the same purpose.

Inside calipers for taking inside dimensions and inside distances are shown in Fig. 65.

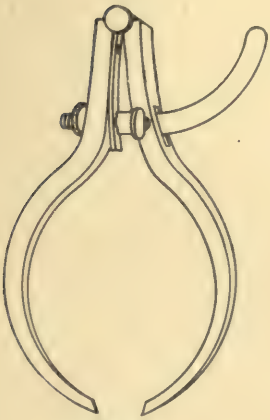


Fig. 63.

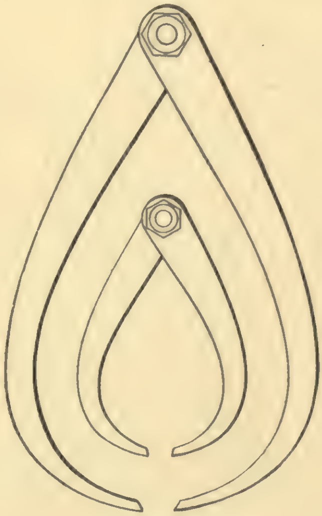


Fig. 64.

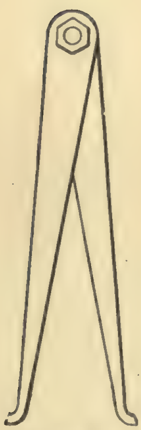


Fig. 65.

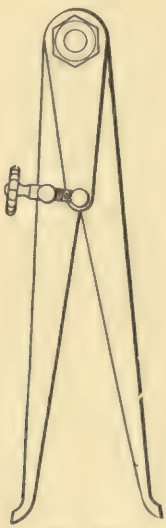


Fig. 66.

The adjustable inside calipers are illustrated in Fig. 66.

Calipers are used for measuring the distances between points external and internal, when a rule could not be used with accuracy.

They are indispensable to the wood turner for measuring the diameters of cylindrical forms and other work while being turned to required dimensions in the lathe. When used by the pattern maker, they may be applied while the wood is revolving, until it has been reduced almost to the required dimensions; after which, when the calipers are used, the lathe should be stopped, to prevent the surface from being marked by the points, and in order to obtain exact measurements.

The calipers should not be pushed or forced over the piece, but in passing over the finished cylinder, the points should touch it lightly without springing the legs of the calipers; otherwise the required dimensions cannot be obtained with accuracy.

MISCELLANEOUS TOOLS.

There remain to be described a few tools, which, while necessary, are so common as hardly to require either illustration or

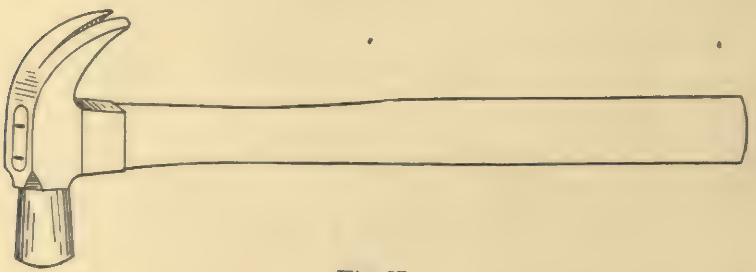


Fig. 67.

description. Among these are the **hammer,** the best form of which for the pattern maker is shown in Fig. 67, and the **mallet,** of which the best form is shown in Fig. 68.

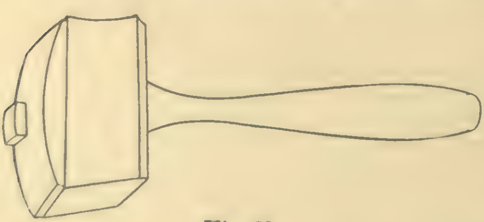
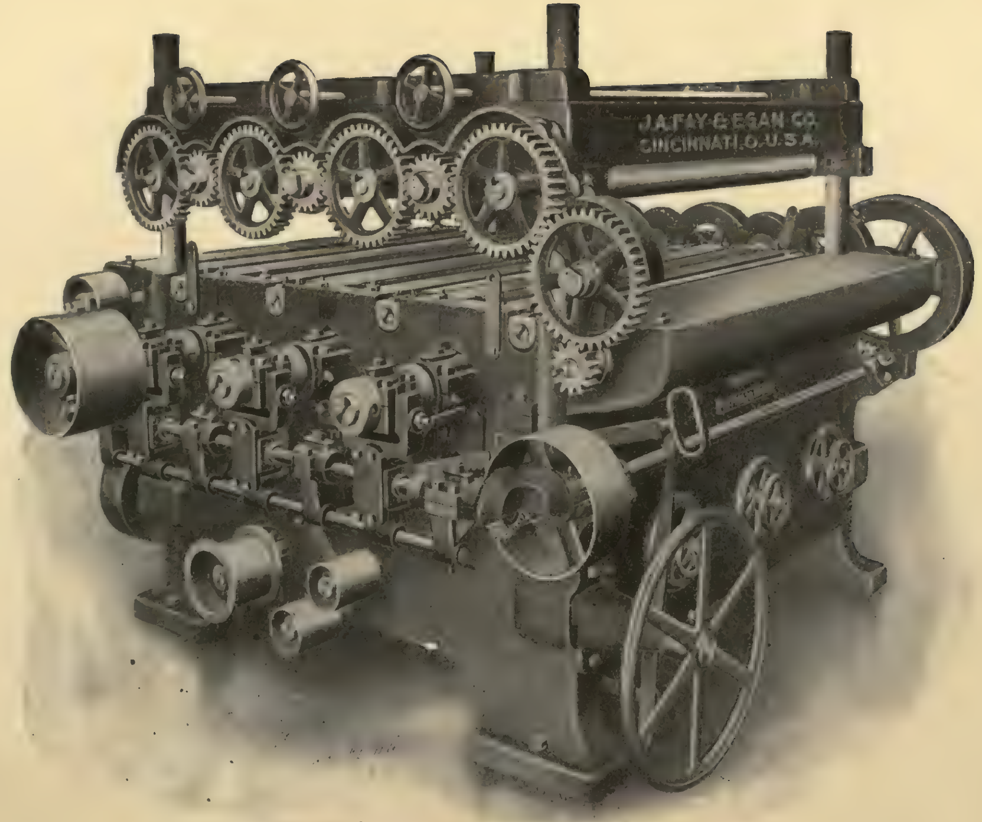


Fig. 68.

A mallet that is to be used on the handle of firmer chisels and other pattern maker's tools, should not be made of hickory or of lignum-vitæ, nor have hard-rubber or hard-fibre facing. Mallets thus made soon mar, splinter, and destroy the tool-handles on



TRIPLE DRUM SANDER.
J. A. Fay and Egan Co.

which they are used. Beechwood and maple furnish the best material for mallet-heads for the use of the woodworker who works in pine and other soft woods. It is true that the mallet-head will not last so long if made of beech or maple wood; but the chisel and gouge handles will be protected, which is a matter of much greater importance.

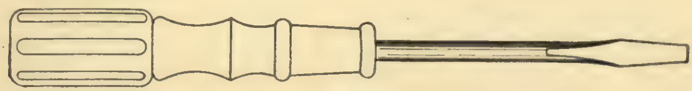


Fig. 69.

Of the **screw-driver,** illustrated in Fig. 69, at least two or three sizes will be found necessary.

The **scratch-awl,** Fig. 70, although used but little at the work-bench (a knife being used in its place for all accurate markings), is indispensable to the pattern maker for laying out the dimensions on his work while it is revolving in the turning lathe. It should be long and slender, as shown, and is used on the revolving wood by placing it over the required graduation of the rule, while the latter is held on the tool rest.

Fig. 70.

Brads and small wire nails must often be driven at such an angle to the grain of the wood, or in such a position, as to make it necessary first to bore a small hole in order to start the brad in the required direction. The brad-awl, illustrated in Fig. 71,

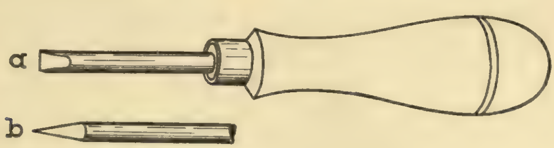


Fig. 71.

is a convenient tool for this purpose. It is commonly ground to a chisel point, as shown at *a*, but will be less liable to cause splitting, and will work faster and with greater ease, if ground to a double spear point, as shown at *b*. The four corners, if kept sharp, will enter the wood and cut faster than the chisel point.

Side-cutting **pliers,** such as are illustrated in Fig. 72, will be found convenient not only for cutting off wire and brads, but for removing small brads and for holding small pieces while being worked to shape.

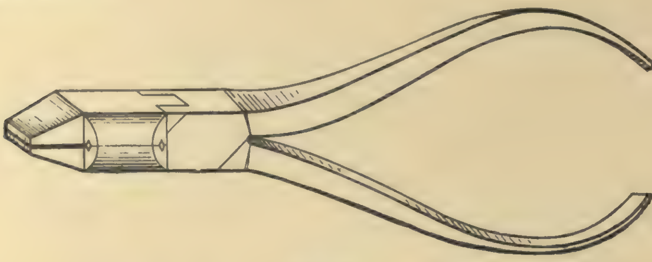


Fig. 72.

Among the tools which cannot be dispensed with are the **brace** and an assortment of **boring bits.** The most desirable style of brace is the **ratchet brace,** illustrated in Fig. 73. The convenience of the ratchet will soon be apparent from the necessity, so often arising, for boring holes or driving screws (with the brace) in angles or close to projections where the full sweep of the brace cannot be taken. Braces are made in many sizes, with sweep varying from 6 inches to 14 inches in diameter.

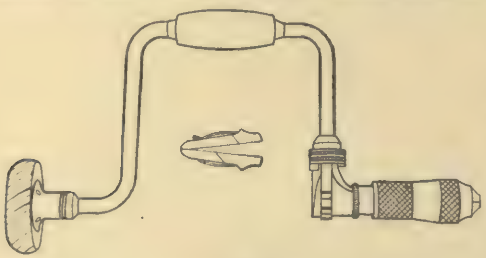


Fig. 73.

A brace with an 8-inch sweep is the most convenient in size for boring holes one inch or less in diameter in soft wood. For larger holes, and especially in very hard woods, a 10-inch or 12-inch sweep will be necessary.

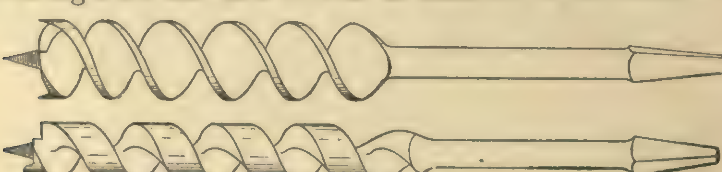


Fig. 74.

Wood-boring bits are made in many styles. The most important are the auger bits, two styles of which are shown in Fig. 74.

They can be bought in sizes running by sixteenths of an inch from $\frac{1}{4}$ inch to 1 inch. For holes larger than one inch, the **No. 2 extension bit,** shown in Fig. 75, is the best. It has two cutters, and will bore a hole of any size from $\frac{7}{8}$ inch to 3 inches in diameter.

Fig. 75.

For screw-holes, the **gimlet bit** or the **twist drill** for wood, both of which are illustrated in Fig. 76, can be bought in all sizes running by thirty-seconds of an inch from $\frac{1}{32}$ inch up to $\frac{3}{8}$ inch:

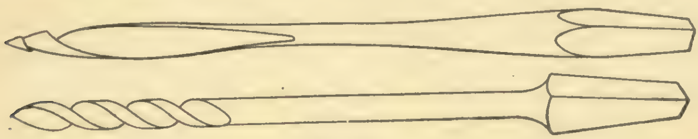


Fig. 76.

The **brace screw-driver,** and also the **brace countersink** for **screw-heads,** are important tools. They are shown in Fig. 77, and can be bought in large, medium, and small sizes.

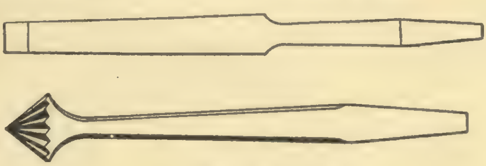


Fig. 77.

The half-round **cabinet file** and half-round **cabinet rasp,** shown in Fig. 78, enter largely into the work of the pattern maker, and should be bought in sizes each of 6 inches, 8 inches, and 10 inches. Larger as well as intermediate sizes may often be found necessary, but will not be needed for ordinary work.

Every pattern shop should have at least one dozen each of three or four different sizes of **hand-screws** or **clamps** similar to that shown in Fig. 79. These are adjustable through wide ranges. They are used for clamping together the material that is being glued up to form the different parts of a pattern, and are convenient also for many other purposes. The all-iron C clamp, shown in Fig. 80, is sometimes useful in positions that are hard to reach with a hand-screw. The method of adjusting and of using the hand-screw will be fully explained later.

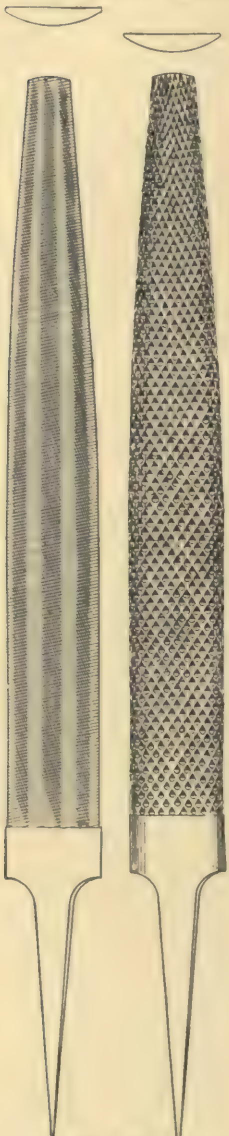


Fig. 78.

RULES.

For all ordinary measurements, a 2-foot, folding **standard rule,** Fig. 81, will be sufficient, but this rule must not be used for laying out or for working patterns, or any part of a pattern or core box, to the required dimensions. For all such purposes a **shrinkage rule** must be used. The reasons are that when a mould made from the wooden pattern in the sand is filled with molten metal, its temperature is very high, and as it cools and solidifies it contracts. Accordingly, to compensate for this, the pattern maker must add to the size of the pattern. In order that this may be done, and exact relations nevertheless be maintained for all dimensions, a shrinkage rule is used. This rule is marked off exactly like an ordinary rule; but if the two are compared, the shrinkage rule will be found to be about $\frac{1}{8}$ inch longer than the other for each foot of length.

The contraction or shrinkage of different metals in the moulds varies greatly, that for cast iron being, as above stated, $\frac{1}{8}$ inch to each foot. For brass, however, the shrinkage is $\frac{3}{16}$ inch to the foot; and for many of the softer metals it is as great as $\frac{1}{4}$ inch per foot.

Shrinkage rules, Fig. 82, are usually made of a single piece

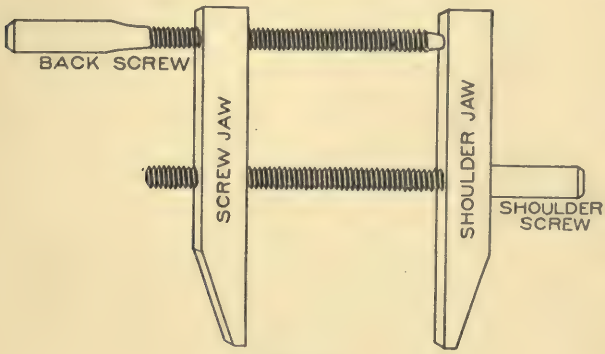


Fig. 79.

of boxwood or beech, those for cast iron being $24\frac{1}{4}$ inches long. for brass $24\frac{3}{8}$ inches long, and for other soft metals $24\frac{1}{2}$ inches

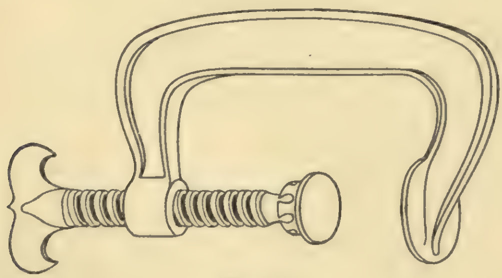


Fig. 80.

in length. They can also be bought made of tempered steel $12\frac{1}{8}$ inches, $12\frac{3}{16}$ inches, and $12\frac{1}{4}$ inches in length. In making use

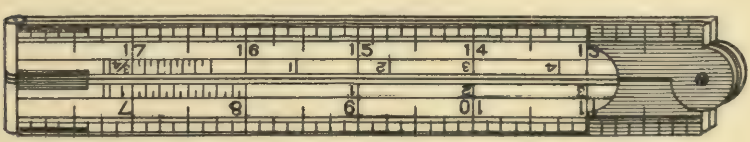


Fig. 81.

of the shrinkage rule. the workman will proceed just as though he were using a standard rule; and when the pattern is completed it will be found to be larger in all its dimensions, just in proportion

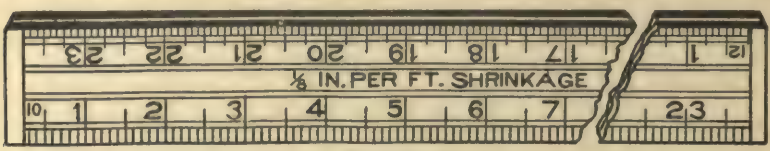


Fig. 82.

as the extra length of the shrinkage rule makes it greater than the standard rule

OIL STONES.

As before stated, new planes, chisels, and other edged tools, if of the best quality, are always sold ground and sharpened, ready for use. When used, however, they soon become dulled, and must then be resharpened, and be so kept as to have a smooth, keen cutting edge, in order to do good work and to work rapidly. The method employed for doing this is the same for all edged tools, whether ground and sharpened on one side or on both sides.

Oil stones are used for plane-irons, chisels, and all flat and straight-edged tools; and **oil slips,** having rounded edges, for gouges, and for all tools having curved edges. They are made of different sizes, and may be found of many and widely different qualities. The best known and most widely used oil stones in this country, and perhaps in the world, are the "Washita," of which the "Lily White Washita" brand, being carefully selected, are the most even in grade and quality, and are the best-adapted natural stone for woodworkers' tools.

The Arkansas oil stones are claimed to be the hardest and finest oil stones in the world. They are composed of nearly pure silica in the form of minute crystals interpenetrating one another, and differ from the Washita only in the minuteness of the crystals and in their more compact arrangement. They are consequently very much harder and cut hardened steel more slowly than coarser grades of stone, but impart a finer and smoother edge to the tool. They are used by wood-carvers, engravers, watchmakers, and others using tools that require a very fine edge or point. They are expensive, and should be used carefully with equal parts of sperm oil and glycerine.

For wood turners' and pattern makers' tools, the sharpening qualities of the "Washita" are unsurpassed; but the quality differs greatly in stones sold under this name, some being uneven in hardness, and some soft and worthless. No trouble will be found, however, if some good selected brand such as the one mentioned above is chosen. A good size for an oil stone is 6 inches to 8 inches in length, and from $1\frac{5}{8}$ inches to 2 inches in width. The thickness does not matter, but the stones usually vary from $\frac{3}{4}$ inch to $1\frac{1}{4}$ inches in thickness.

The oil slip should be about $4\frac{1}{2}$ inches in length, and from $1\frac{3}{4}$ inches to 2 inches in width, tapering from $\frac{5}{8}$ inch on one edge to $\frac{3}{16}$ inch on the other, both edges being rounded as shown in Fig. 83.

In using the oil stone, care should be taken to *hold the bevel of the tool flat, or nearly flat, on the stone*, so that the cutting edge may be kept thin and in easy working condition. The stone is held stationary on the work-bench, and the tool is moved for-

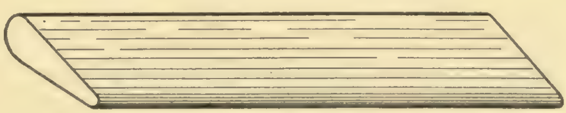


Fig. 83.

ward and backward over its face. In the use of the oil slip, on the other hand, the tool is held stationary, with the cutting edge or end up, and the slip is rubbed over the beveled surface with a circular motion or stroke, until a keen, sharp edge has again been imparted to it. An abundance of oil should always be used in order that a finer and smoother edge may be given to the tool, and the pores of the stone be kept clean and free from glazing.

In the last few years an entirely new variety of oil stone and oil slip has been placed on the market. It is called the **India oil stone**, and is made from corundum, the hardest of all mineral substances except the diamond. These stones have wonderful cutting qualities, and differ greatly from other oil stones in that they cut steel much faster, impart better edges, and do not glaze. They are also of uniform texture throughout. India oil stones are furnished in three grades—coarse, medium, and fine—and in all required shapes, a few of which are shown in Fig. 84. Only the "fine" stones are adapted for woodworking tools and for those classes of tools requiring a fine cutting edge.

GRINDSTONES.

Second in importance to a good oil stone is the grindstone, power-driven if possible. It should not be too close-grained. A rapid-cutting stone, even if moderately coarse, is greatly to be preferred, as all ground edges must be finished on the oil stone however finely they may have been ground on the grindstone.

A stone about 36 inches in diameter when new, is a good size; and can be bought with a suitable cast-iron trough underneath, and also with an arrangement for supplying the water necessary to keep the stone wet.

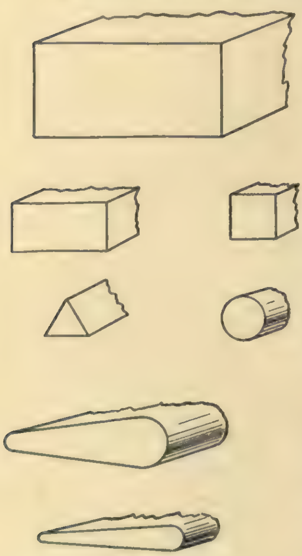


Fig. 84.

In all stones there will be found great differences of hardness in different parts. Stones soon lose their cylindrical shape and must be turned true. A piece of gas-pipe or an old file will be found excellent tools for this purpose, but they must be used without water.

In using the grindstone for plane-irons, chisels, and other tools that must be ground with a long bevel, or to a thin edge, it is better to stand so that the stone runs toward the cutting edge of the tool, as shown in Fig. 85. This position grinds the tool much faster, and less of a feather will be turned up on the final edge.

Scraping tools, however, and indeed all tools having a very short bevel, or whose edges are ground to a very obtuse angle, may be held so that the stone will revolve away from the cutting edge of the tool, this position being less liable to cut hollows in the face of the stone. This method of grinding, however, is too slow for tools having a long bevel, and which for that reason require more grinding.

When to use the grindstone is a question that often occurs to the beginner, who sometimes confuses the use of the grindstone with that of the oil stone. The grindstone is not in any sense an instrument for *sharpening* woodworkers' tools. When a chisel or a plane-iron has been sharpened on the oil stone for several successive times, the bevel is gradually worn shorter, and its shape changed from that shown at *a*, Fig. 86, to a shape similar to that

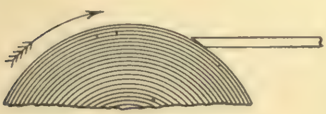


Fig. 85.

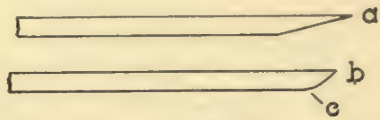


Fig. 86.

shown at *b*. When the length of the bevel is thus reduced, the angle of the cutting edge is too obtuse to do good work, or to work easily. The metal at *c* must then be ground off on the grindstone, and the bevel of the tool restored to its former correct shape as shown at *a*, after which the cutting edge must be sharpened and finished on the oil stone.

LATHES.

Of all power-driven machines, the most indispensable to the pattern maker is the **wood turning lathe.** In a small shop where small patterns only are made, a 14-inch or a 16-inch speed lathe, such as is shown in Fig. 87, may prove sufficient for all purposes; but if only one lathe can be afforded, it should be a regular pattern-maker's lathe, similar to that illustrated in Fig. 88.

The latter differs from the speed lathe in that the head-stock spindle extends through the left-hand bearing, and is fitted to receive face-plates and chucks, the same as on the inside end.

The arrangement of the countershaft is also such as to give a much wider range of speed to the lathe head, so that pieces of very large diameter may be turned at a speed proportioned to their sizes. These lathes are also fitted with a hand-feed slide rest —either compound, as shown in the illustration, or a plain sliding tool-holder moved by a rack and pinion, as may be desired. The tail stock is so arranged as to be adjustable for turning long cylinders, either tapering or straight, as may be required. When not in use the slide rest may be removed from the lathe, and the ordinary tool rest and rest socket substituted in its place for hand turning.

The speed at which a lathe should be run is always indicated by the manufacturer, the countershaft usually running at a speed of 500 to 550 revolutions per minute.

A variety of **chucks** and **face-plates,** used for holding the work, are always furnished with a lathe. Some of these are shown

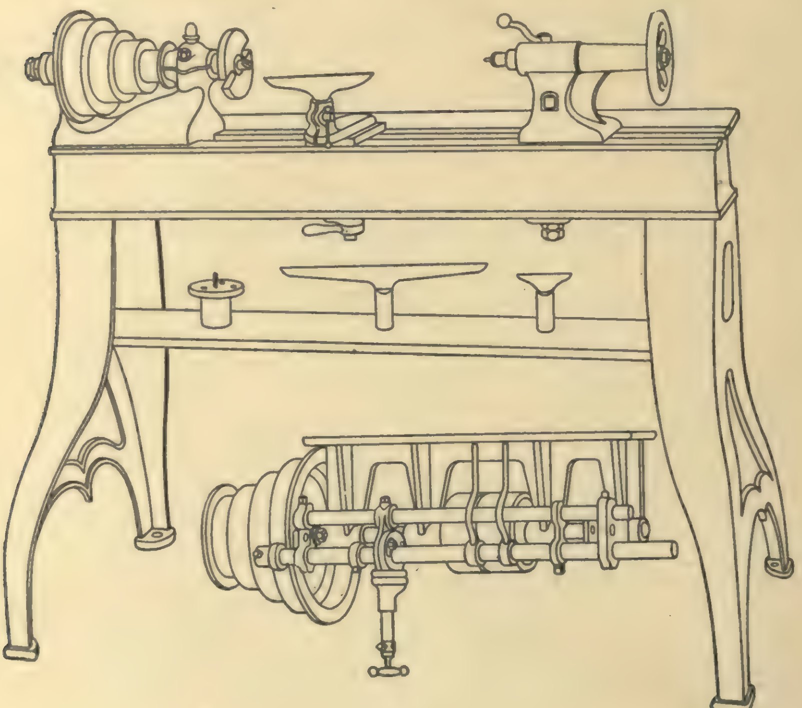


Fig. 87.

in the engraving, the screw chuck being shown at *a*, Fig. 88; and two of the iron face-plates are shown, one on each end of the spindle.

But in addition to these face-plates, which really form the base only for chucking the pattern, **wooden chucks** must be used intermediate between the iron face-plate and the pattern. These wooden face-plates are constructed in a variety of ways by different pattern makers; but for small patterns it is necessary to use only a plain board $\frac{7}{8}$ inch to $1\frac{1}{4}$ inches in thickness and of a slightly greater diameter than the required pattern. This board is screwed fast to the iron face-plate as shown in Fig. 89, to which, after being placed in the lathe and turned true, the pattern is attached, as will be fully illustrated and described farther on. For

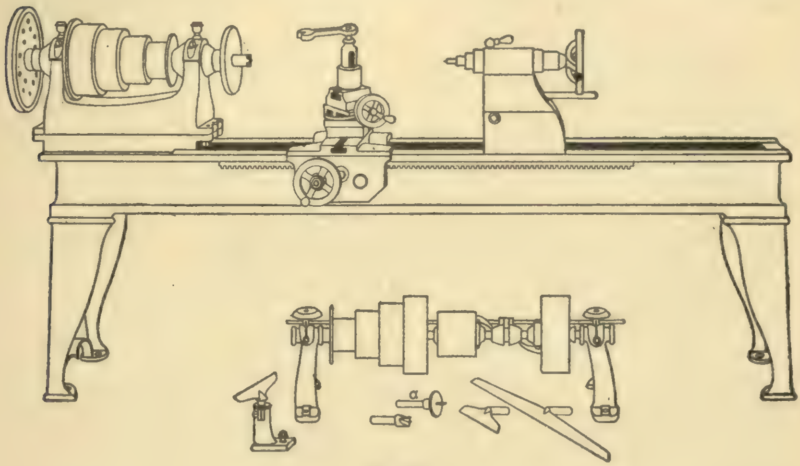


Fig. 88.

patterns of a medium size, say 20 inches to 30 inches in diameter, the board should be stiffened by means of a wide wooden bar firmly screwed across the back, as in Fig. 90.

When chucks are needed for very large or heavy work, the chuck, in order to prevent vibration, must be strong in proportion. It is best made as illustrated in Fig. 91, in which the front of the chuck, as shown at *a*, will be least affected by the moisture in the air if left unglued, or at best only tongued and grooved, being held together by the cross-bars only, as shown at *b*, to which it is firmly screwed, without glue. This chuck is simple and cheap, and will be found in practice much stronger and more rigid than one built up out of sectors or in a more elaborate way.

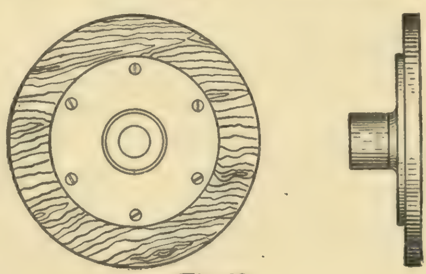


Fig. 89.

LATHE TOOLS.

Of lathe hand tools the first to be considered, as also the first to be used, is the **gouge.** It is used for reducing the stock to be turned, from a rough or rectangular shape to a cylindrical form, preparatory to smoothing and finishing. It is ground and beveled on the back or convex side, and the shape of the cutting edge should be of the same curvature as the inside, or upper side, of the tool. Gouges are made in all sizes, one of which is illustrated in Fig. 92; but for the pattern maker's use four gouges, ranging from $\frac{1}{4}$ inch to $1\frac{1}{4}$ inches, will be found sufficient for all purposes.

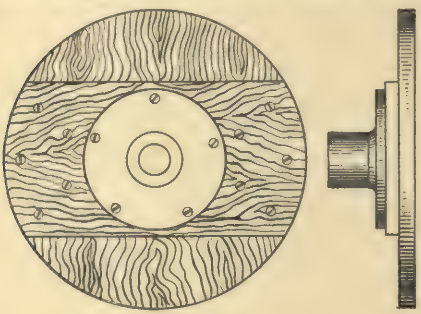
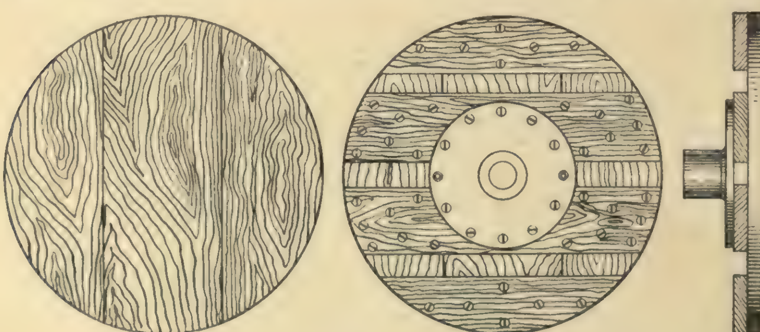


Fig. 90.

Before using the gouge, and indeed any lathe-cutting tool, the workman should take care to see that the tool rest has been elevated above the center line of the lathe centers, from $\frac{1}{4}$ inch for small work to 1 inch or more for large work. The position of the gouge, when in use, is horizontal and at about a right angle to the tool rest. It should not, however, be laid on the rest so as to use only the extreme point of the tool, but should be tilted over, first to one side and then to the other, so as to bring all parts of the cutting edge, successively, in contact with the wood that is being turned.



a Fig. 91. *b*

The gouge may be used by the beginner without hesitation, as in no position, whether tilted or on its back, will it catch or rip into the wood. The tool should be held firmly by the extreme end of the handle, in the right hand, while the left hand rests against the tool rest, the blade of the tool being grasped lightly with the fingers, and passing through and under the left hand while resting on the tool rest.

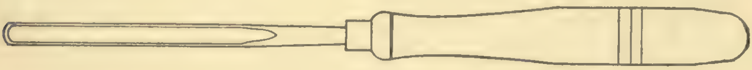


Fig. 92.

The turning gouge, being curved, can be used only as a roughing-down tool or for turning out hollows, and cannot be used for finishing. It will not make a straight, true, or smooth surface. For this purpose, in common and ornamental turning, the **skew chisel**, one size of which is shown in Fig. 93, is used. This form of chisel is made in all sizes from $\frac{1}{8}$ inch to $2\frac{1}{2}$ inches in width, but, unlike the gouge, requires considerable practice and skill for its successful use.

Fig. 93.

The skew chisel is held slightly tilted so that while the short edge of the blade touches the tool rest, the long edge will be slightly above the rest, so that the long corner of the skew point extends *up* and well *over* the cylinder which is being smoothed, thus preventing the long skew point from catching and tearing into the work. All the cutting must be done with the short part of the skew edge, say one-half inch only of the cutting edge, the tool resting not only on the tool rest, but resting also firmly on the cylinder that is being turned, just as a plane rests on a board while cutting and removing the shavings from its surface. The right position for this tool is hard to obtain at first, and can be acquired only by patient and continued practice. In no case, however, should the skew chisel be held *flat* on the tool rest. or used as a scraper, this not being allowable or good practice either in common or in ornamental turning. One skew chisel each of the $\frac{1}{4}$-inch, $\frac{1}{2}$-inch, 1-inch, and $1\frac{1}{2}$-inch sizes will be found sufficient for all ordinary work.

While the skew chisel works with great rapidity and does smooth and very satisfactory work in all kinds of ornamental turning, the dimensions obtained with this tool are not so accurate for pattern work as those obtained by the regular pattern maker's **scraping tools.** These tools, whatever may be the shape of the points or cutting edges, are all flat like the skew chisel, and are ground or beveled on one side only. Indeed there is no better wide scraping tool for large surfaces than a common firmer chisel after it has been worn short so as to be free from vibration.

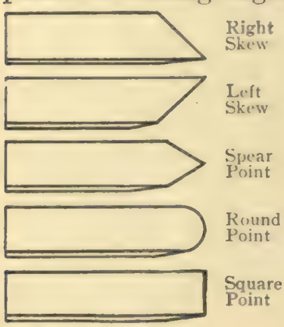


Fig. 94.

Scraping tools are made in many forms and shapes, and are ground by the workman to suit the requirements of his work. A few of the many shapes in common use are illustrated in Fig. 94.

These tools should be ground with a very short bevel, and must be sharpened much oftener than a cutting tool. The revolving wood, passing at right angles to the sharp edge wears it away more quickly than it can a cutting tool, for the latter is also worn away on the slanting side of the bevel.


Fig. 95.

A very necessary tool for all kinds of wood turning is the **parting** or **cutting-off tool,** shown in Fig. 95. This is used as a scraping tool for cutting recesses in the work and for cutting off finished work from the face-plate, and will also be found useful for many other purposes.

SAWING MACHINES.

As a time-saving and labor-saving machine a good **circular saw bench** is necessary in every well-equipped pattern shop.

The saw bench of which two views are shown in Fig. 96, is unsurpassed in capacity and in the variety of work for which it

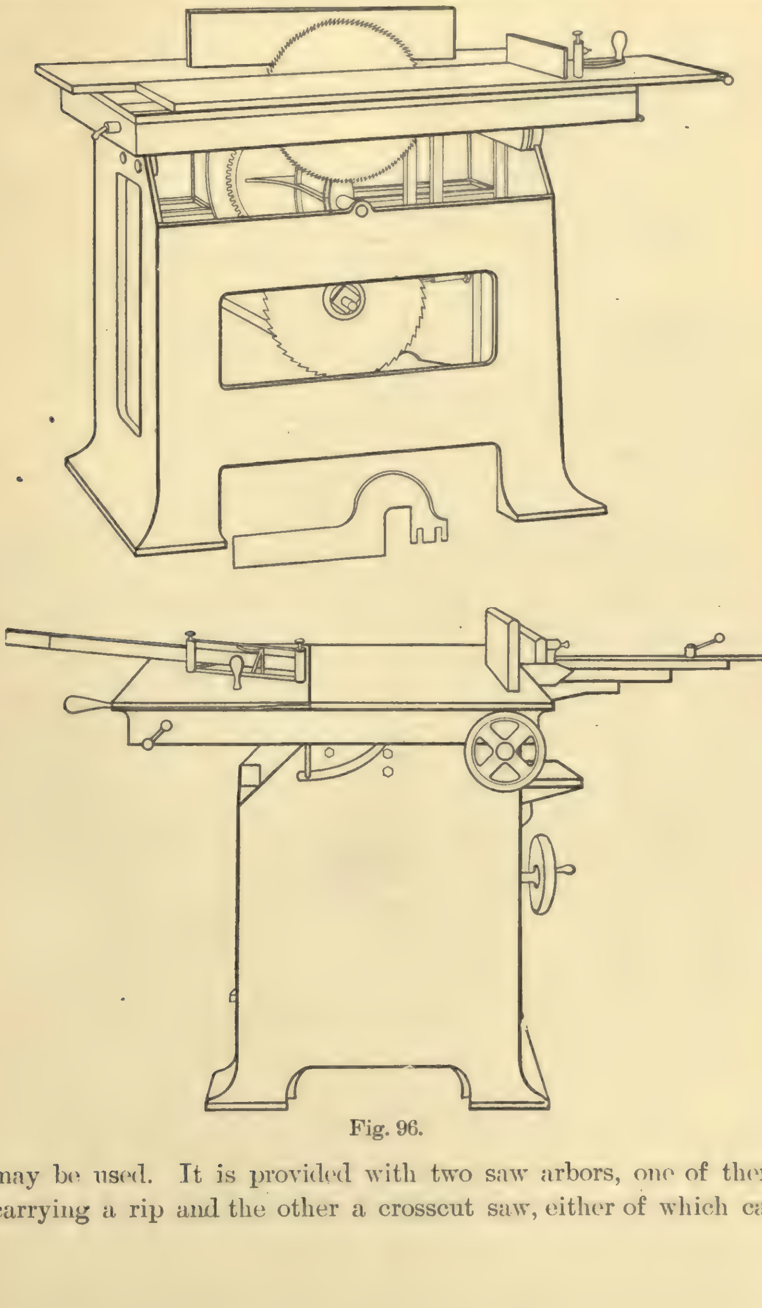


Fig. 96.

may be used. It is provided with two saw arbors, one of them carrying a rip and the other a crosscut saw, either of which can easily and quickly be raised to a cutting position. The front half of the table is made to slide, while the whole table can be tilted to an angle of 45°, and will remain in any position desired without clamping. As shown, it is provided with adjustable gages for crosscutting or mitering, and with an adjustable fence for ripping, all of which are removable at will, leaving the whole upper surface of the table clear. Fig. 97 gives a view of the table from above. As in the case of the turning lathe, the intended speed of the saw countershaft is indicated by the manufacturer.

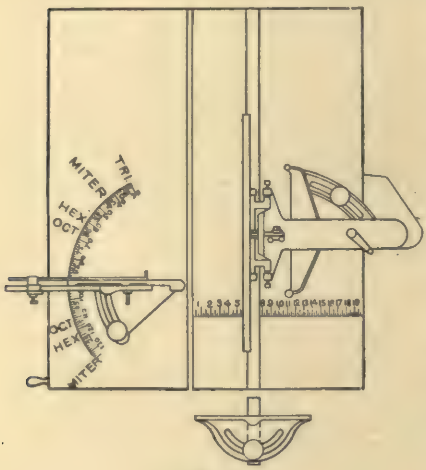


Fig. 97.

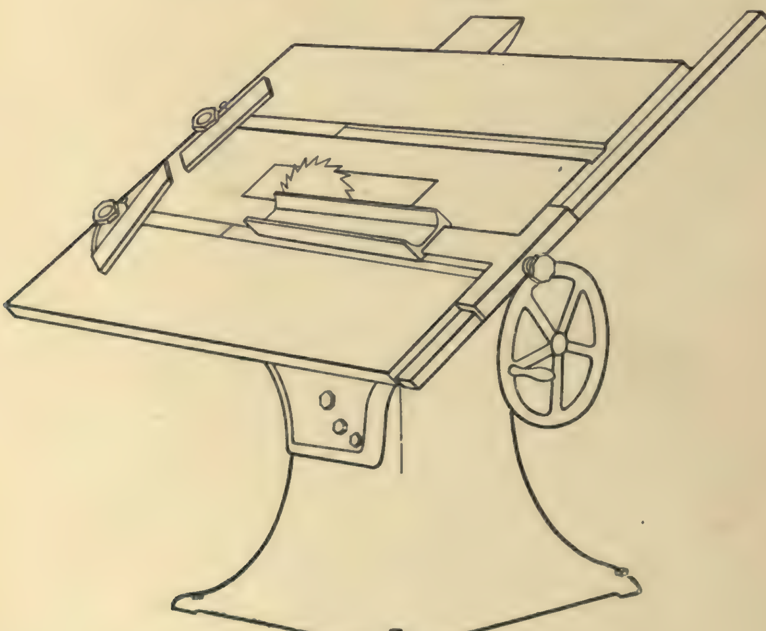
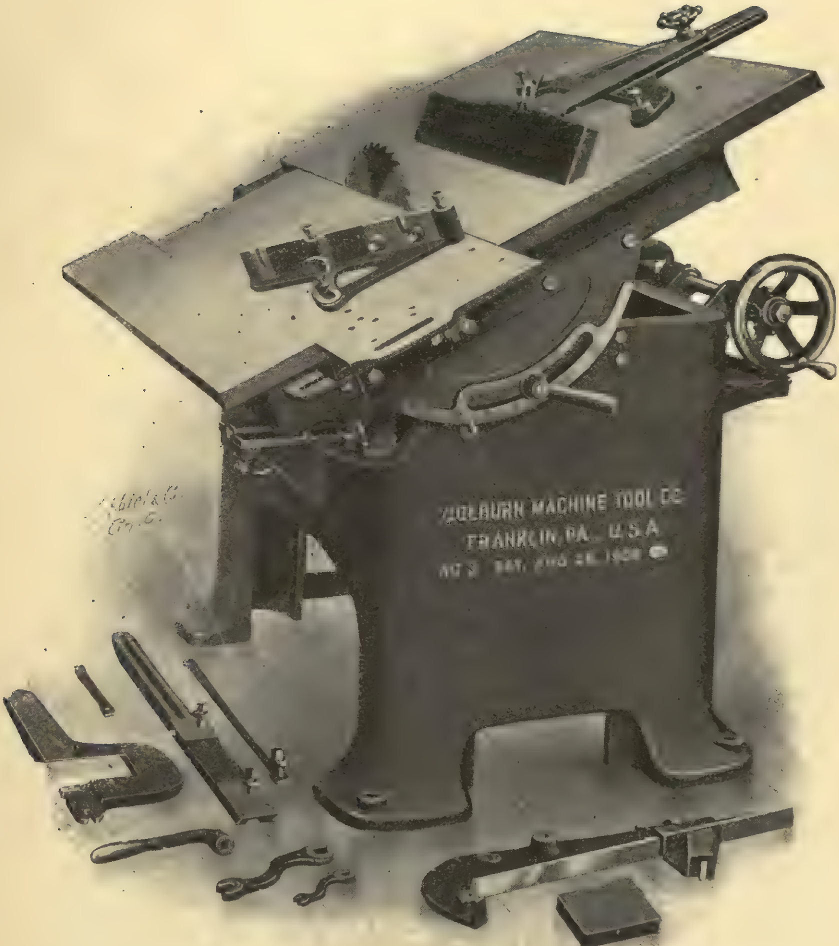


Fig. 98.



UNIVERSAL SAW TABLE.
Coburn Machine Tool Co.

The single-arbor circular saw bench shown in Fig. 98 is a less expensive machine than that just described; but the time lost in having continually to change the saw on the single arbor from rip to crosscut and back again for pattern work, is a very annoying as well as expensive inconvenience.

BAND AND SCROLL SAWS.

A good **band saw,** such as the one illustrated in Fig. 99, is indispensable for cutting the curves and irregular shapes that form a part of so many patterns. The best machines of this description have a tilting table which can be set and clamped at any angle, enabling the workman to give the required level or draft to his work.

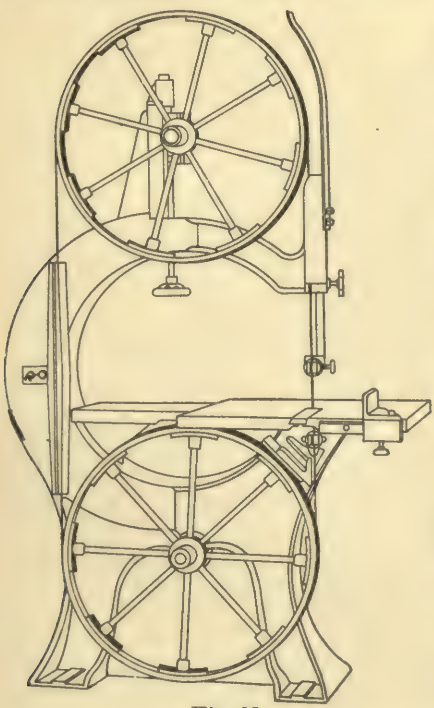


Fig. 99.

With a sharp and well kept saw, there is no more rapid or correct method of cutting out and making circular core boxes of all sizes whose length is within the capacity of the machine. The block from which the core box is to be made must be cut perfectly square on the end that is to rest on the saw table; and, if this end of the block is not large enough to give sufficient base to hold it in an upright position, the block can be supported against the blade of a try-square, or, better still, against a wooden bracket made for the purpose.

The **scroll saw,** illustrated in Fig. 100, is necessary for cutting inside curves and openings in which a band saw could not be used. Like the band saw it should have a tilting table. Where both saws cannot be afforded, the scroll saw will take the place of both.

While not working so rapidly as the continuously cutting blade of the band saw, it is, when kept sharp and in good running condition, a great time- and labor-saving machine.

PLANING MACHINES.

Because of the fact that pattern lumber can be bought already dressed to any required thickness, a planing machine is not found in every pattern shop. The ordinary surface planer, however, will not take the twist, or wind (*i* as in *find*), and the curves out of the surface of the lumber—a matter of very great importance in pattern work, and one which requires a great deal of time if the planing is done by hand.

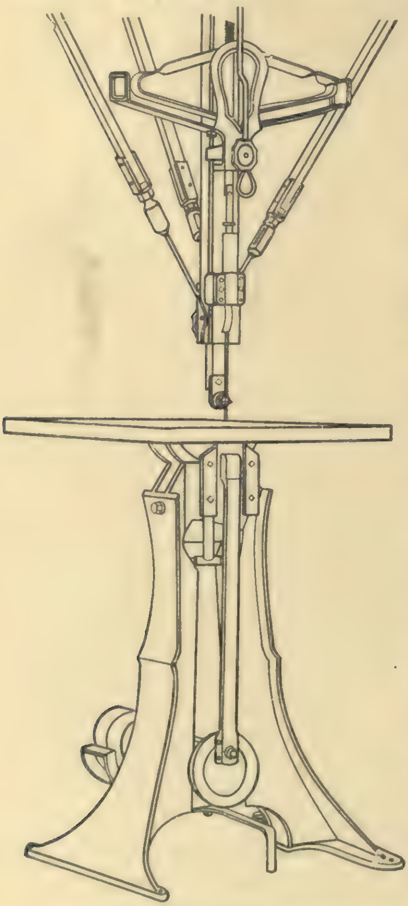


Fig. 100.

The **hand planer and jointer,** illustrated in Fig. 101, is almost indispensable, not only for facing the sides of boards perfectly true, straight, and free from wind, but also for jointing the edges, and for making perfectly-fitting glue joints in a manner superior to any hand work. These machines can be bought in widths of from twelve to thirty inches. A machine sixteen inches wide is a very desirable size for pattern work.

It will readily be seen that the running of a board over the hand planer, while facing the surface straight and true, will not reduce the piece to a uniform thickness. To avoid the necessity for much hand work in accomplishing this result, first face the piece on the hand planer so as to make one true side, and then run it through a surface planer similar to the one illustrated in Fig. 102. If they can be afforded, both of these machines (especially the hand planer) will return large profits on the money invested in them, because of the time

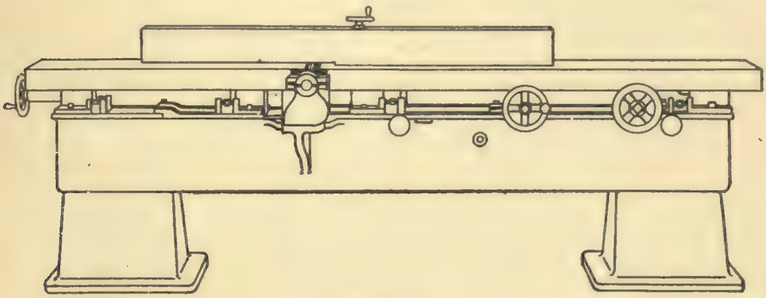


Fig. 101.

and labor saved and the superior quality of the work done.

Among the many labor-saving tools of late years, there is perhaps none more popular and none more indispensable in a

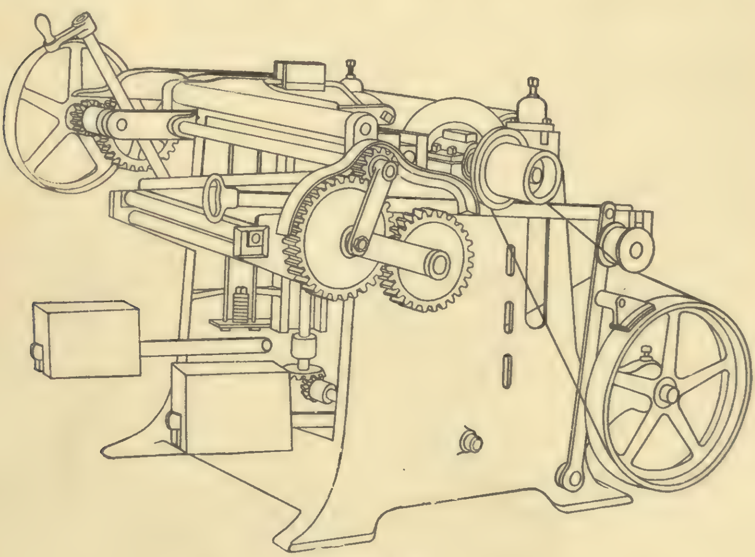


Fig. 102.

pattern shop than the **universal wood trimmer.** It will cut any end or angle within the capacity of the machine; and an end which would take from ten to fifteen minutes to square and true up correctly by hand with square and plane or chisel, can be finished in as many seconds with this tool. It is made in many sizes, from the small bench trimmer, two views of which are shown in Fig. 103, to the large machine illustrated in Fig. 104. The former will cut 6 inches wide and 3 inches high. The larger machine will cut 20½ inches wide and to a height of 7½ inches.

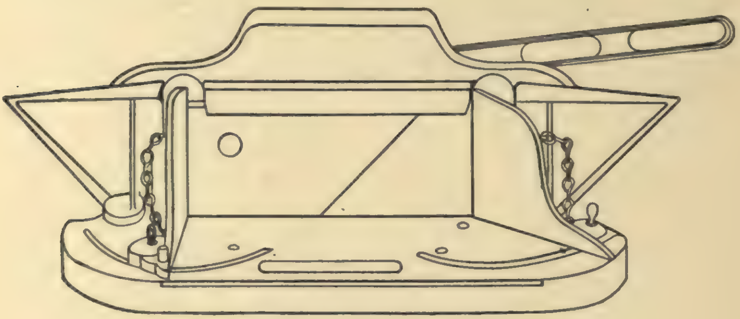


Fig. 103—Front View.

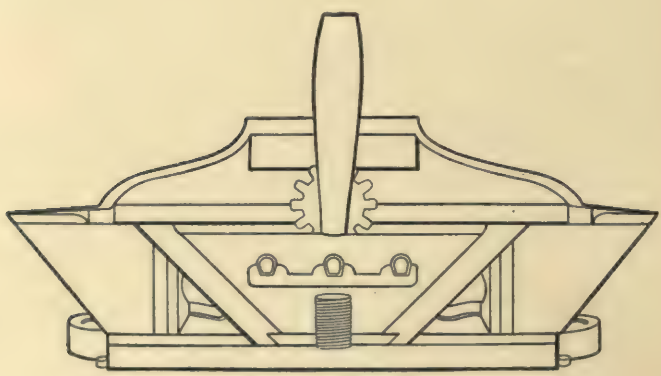


Fig. 103—Rear View.

The small No. 0 machine, shown in Fig. 103, is so comparatively inexpensive, and the time it will save so great, to say nothing of the quality of the work produced, that it should be on the bench of every pattern maker. These machines will cut the acute angles between 45° and 90°, and the obtuse angles between 90° and 135°.

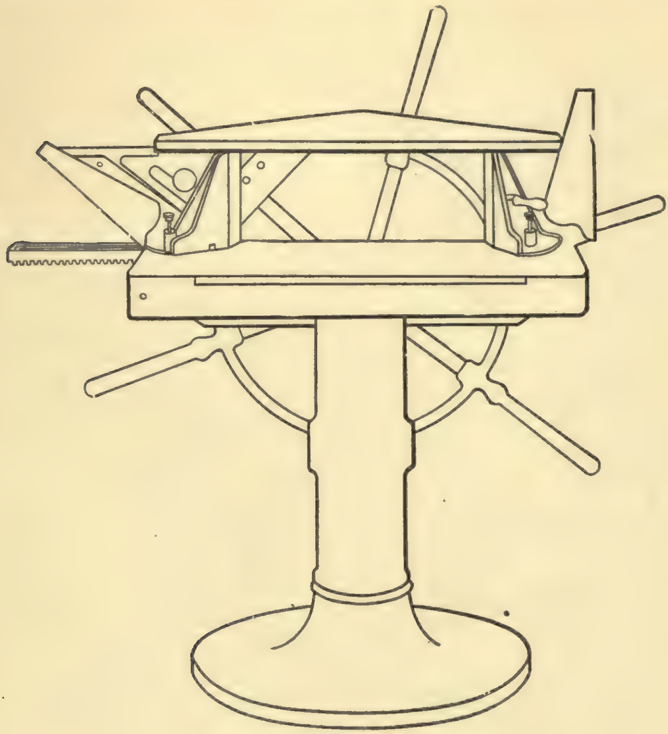


Fig. 104.

METHODS OF MOULDING.

As has already been said, it is necessary that the patternmaker should have some knowledge of moulding in order that he may construct his patterns so that they can easily be removed from the sand. A brief description of the general method employed will suffice.

Ordinarily, a casting is made in a **flask** consisting of two parts, each containing its complement of sand. The upper part is called the **cope**, and the lower part the **nowell** or **drag.** The pattern is sometimes made in two pieces that *part* along the line separating the cope and the drag. Thus in Fig. 105 the pattern separates with the flask, on the line A B; and when so separated, the cope is turned upside down and the portion of the pattern C is lifted out. The part D is lifted out of the drag in the same way.

In the case of moulding a hollow object, the internal cavity in the casting is formed by means of a dry sand **core**, which rests in impressions made in the sand by **core prints** attached to, and forming a part of, the pattern. To illustrate this, let it be required to cast the hollow cylinder shown in Fig. 106. The wooden pattern necessary to produce this hollow cylinder is shown in Fig. 107, which, as will be seen, represents the cylinder only externally by the part A.

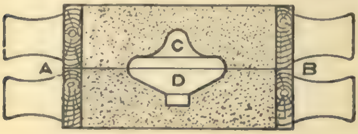


Fig. 105.

The core prints, one on each end of A, are represented by *x* and *y*. These projections form part of the pattern, and make their impressions in the sand with the part A, which alone represents

Fig. 106.

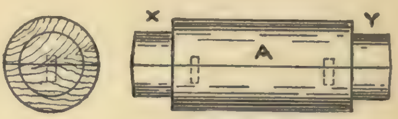


Fig. 107.

box will be the extreme length of the pattern including *x* and *y*, and the inside width will be the exact diameter of the core prints. In this case, the core being a cylinder, only a half core box (Fig. 108) is used. In it are made two semi-cylindrical cores, which, after being dried, are cemented together, thus forming the complete cylindrical core required.

To mould this halved or *partea* pattern as it is called, the upper half of the pattern is laid on the moulding board, and the *drag* is turned over it with the bottom side of the drag up and the parting side on the moulding board, as shown in Fig. 109. After being "rammed up," the drag and moulding board are turned over and the board removed, when the parting of the pattern will be exposed, the half pattern being imbedded in the sand.

Fig. 108.

The second half of the pattern is now placed in position on the first, and dry **parting sand** is spread over the surface of the wet or "green" sand; the cope is put in position on the drag, as shown in Fig. 110, and rammed up. Upon the cope and the drag

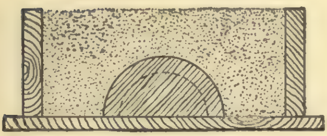


Fig. 109.

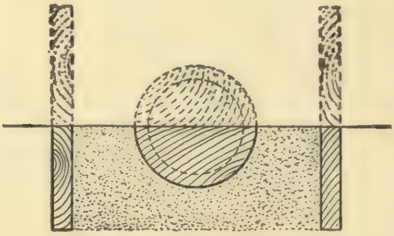


Fig. 110.

being separated, the sand will separate on the line to which the parting sand has been applied, which, as will be seen, is the line of parting of the cope and the drag, one half of the pattern remaining in each.

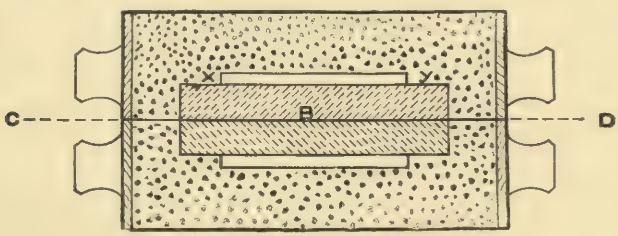


Fig. 111.

After the pattern has been removed (one half from the cope, and the other half from the drag), the completed dry sand core is placed in the moulds made by the core prints x and y. This core B is shown in position in Fig. 111 and entirely fills the parts of the mould made by x and y, leaving between itself and the surface of the mould made by A, room for the metal to be poured which is to form the required cylinder.

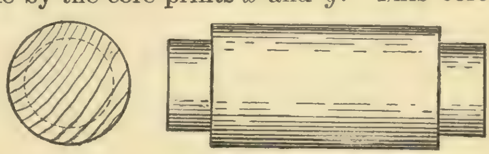


Fig. 112.

In moulding the above cylinder it is not necessary that the pattern should be parted (made in two halves) as shown in Fig.

107. Patterns for small work, and even for large castings, are often made in one piece, as shown in Fig. 112. To mould this solid pattern it is placed on the moulding board with sufficient

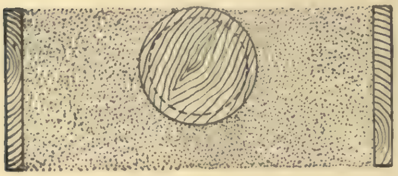


Fig. 113.

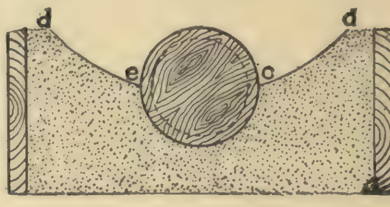


Fig. 114.

sand to keep it from rolling, and the drag is inverted over it as before. When the drag has been rammed up, it is turned over, and will then present the appearance shown in Fig. 113, the entire pattern being embedded in the sand. The sand is now cut away and removed, as shown in Fig. 114, down to the center line of the pattern. The cut sand is smoothed; and, after dry parting sand has been applied to the surface of the wet sand, the cope is placed in position and rammed up as usual.

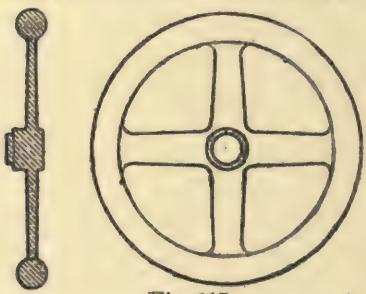


Fig. 115.

Upon the cope being removed, the sand will part along the lines *d e* and *c d*, leaving one-half of the entire pattern exposed. The pattern can now be lifted out, the core placed in position,

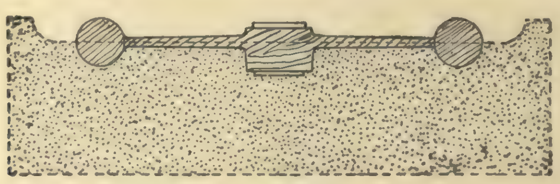


Fig. 116.

and the cope returned to its place on the drag, when it is ready for the pouring, as in Fig. 111.

Another example of a one-piece pattern is the small brass hand wheel shown in Fig. 115. The pattern for this wheel is placed on the moulding board, and the drag inverted over it and rammed up. After the drag has been turned over, the sand is cut away and removed, not only down to the center of the rim, but also to the center line of the four arms, as shown by the dotted lines in Fig. 116.

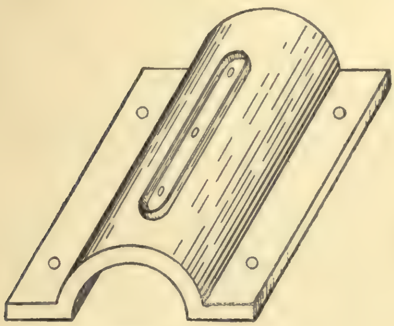


Fig. 117.

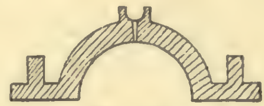


Fig. 118.

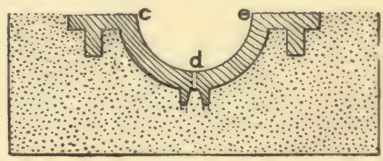


Fig. 119.

All cut surfaces of the sand are smoothed, parting sand is sprinkled over the parting thus made, and the cope is placed in position and rammed up. When the cope is lifted off, the sand will part half way down on the arms and rim, allowing the pattern to be taken out with ease.

Still another example in which a single-piece pattern can be used, is shown in the journal-box cap illustrated in Fig. 117. A cross-section of the pattern through two of the bolt-hole core prints is shown in Fig. 118. The pattern is placed on the moulding board in the inverted drag and is rammed up as usual. When the drag is turned over, the position of the pattern in the sand is as shown in cross-section in Fig. 119. The sand that may have entered

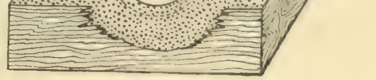


Fig. 120.

the curve *c d e* is lifted out, and the necessary "draft" is given to the sand at the two ends of the opening *c d e*, as shown at *a*, Fig. 120. The cope is next placed in position, and when this has been rammed up and lifted off, the sand lying in the curve *c d e* will be lifted with it. The pattern is now removed; the bolt-hole cores are placed in position; and the cope is returned to its place on the drag.

In this case the core prints should be in length at least twice the thickness of the metal through which the hole is to be cast, and the length of the cores will be equal to the thickness of the metal plus the length of the prints.

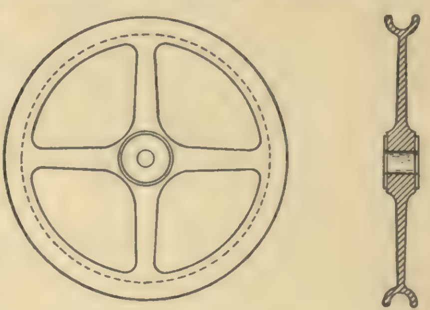


Fig. 121.

In the small sheave pully, Fig. 121, we have an example of a casting the construction of the pattern for which, so as to make it easily removable from the sand, may give some trouble to the beginner. The pattern is shown in cross-section in Fig. 122, and is moulded in a two-part flask. At first it would seem impossible to place the pattern in the sand so that either half could be removed when the cope and drag are separated on the parting line of the pattern. This is readily accomplished, however, as follows:

Fig. 122.

The half pattern C is placed in the inverted drag, with the parting downward on the moulding board, and is rammed up in the usual way. After the drag is turned over, the sand is cut away and

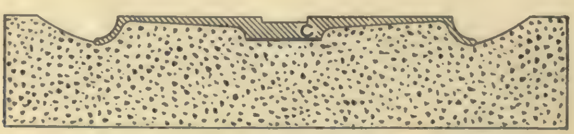


Fig. 123.

removed to the center of the rim edge, as shown in Fig. 123. The cut is carefully smoothed, and parting sand applied to the cut surface. The part A of the pattern is placed in position on C, and is rammed up carefully, the sand being then cut away to the center of the rim edge of A. Parting sand is applied to the new surface, after which the cope is placed in position and rammed up.

When the cope and drag have been separated, the upper half A of the pattern is taken out, and the cope is returned to its place on the drag. The whole flask is now turned over, and the drag lifted off the cope, when the ring of green sand Z, Fig. 124, will rest on the cope sand and the part C of the pattern is taken out. We thus have two partings of the sand mould, but only one parting of the flask.

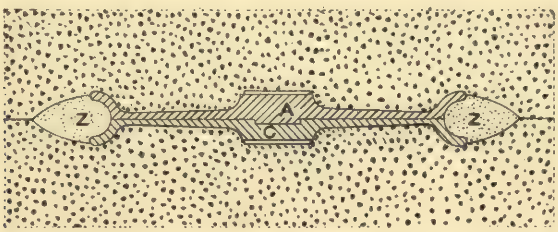


Fig. 124.

Many other examples might be given, as the case of the common two-flange pulley, which, when small, is often moulded in this way.

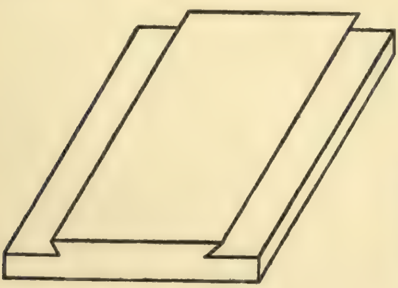


Fig. 125.

Fig. 126.

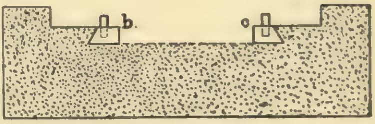


Fig. 127.

It is frequently the case that parts of the pattern will overhang so that the pattern cannot be removed from the sand in any direction, even if parted. In such cases the overhanging parts are fastened loosely to the main part of the pattern by wires or wooden pins. An example of such a casting is shown in the slide, Fig. 125. A cross-section of the pattern for this slide is shown in Fig. 126, in which the two overhanging parts are held in position by the use of pins. After being rammed up, the part A is removed, leaving the parts *b* and *c* still in their positions in the sand, as in Fig. 127. These may now be carefully moved toward the center of the opening and lifted out

Fig. 128.

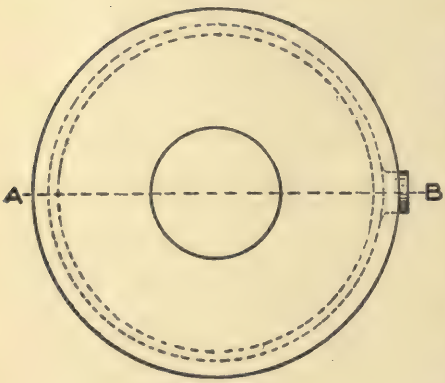


Fig. 129.

In some cases there is not sufficient room, when the main part of the pattern has been taken from the mould, to remove the projecting pieces. In such cases, the overhanging pieces or projections must be made by using dry sand cores. To illustrate this, we shall consider the pattern for the small cast-iron turbine case illustrated in Figs. 128 and 129. A section view of the casting through A B (Fig. 129) is given in Fig. 130.

The pattern is parted on the line C D and will form its own core. The boss *a*, however, will prevent the main part of the pattern from being removed from the sand, and if *a* were made loose it could not be taken out through the narrow space made by the thin side of the pattern. To overcome this difficulty a core print is fitted on the side, extending from the parting line C D to the bottom edge of the pattern, as illustrated in Figs. 131 and 132; and in the impression made by this core print a dry sand core, formed in the core box shown in Fig. 133, is placed. It will readily be seen that this core will, in connection with the pattern, form a mould which will give the casting required.

Fig. 130.

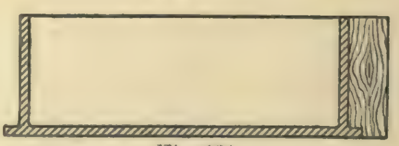


Fig. 131.

Examples in "Methods of Moulding" could be multiplied indefinitely, but the foregoing, we think, will give such suggestions as will enable the beginner in pattern making to construct all

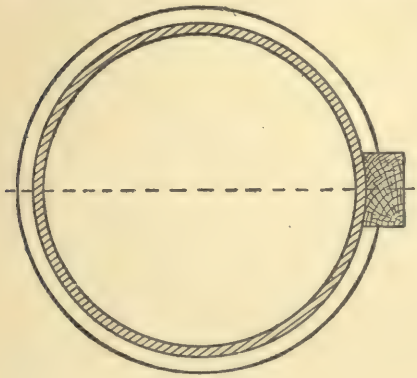


Fig. 132.

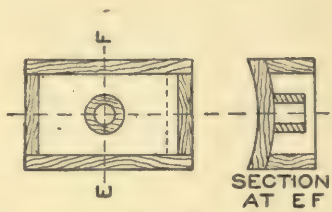


Fig. 133.

ordinary patterns so that they can easily be removed from the sand without injury to the mould.

PATTERNS FROM DRAWINGS.

As already explained, the pattern maker must understand working drawings in order to construct patterns from them directly. These drawings are usually made to a scale much less than the actual size of the required work, and always represent the completed or *finished* machine or one of its parts.

Drawings are made for the machine shop to guide the machinist in cutting, turning, planing, and fitting the parts given, so as to produce in the castings the shapes, sizes, and general requirements of the articles to be constructed. Hence there is less liability for mistakes after the castings reach the machinist, as he has before him not only the drawing with its accurate dimensions to work from, but also the castings for the machine or its parts, from all of which the construction and uses of these several parts can easily be understood.

On the other hand, the pattern maker, with the aid of the same drawing, must *imagine* the casting before him, and must build something in wood which will produce that casting in metal. This pattern, in some cases, will be a duplicate of the required casting, but more often it has only a general resemblance to it, with core prints attached, and is external only, with nothing to show the internal openings, chambers, and winding passages that must be provided for by "coring." The core boxes, in which the cores are to be formed, are not shown in the drawings furnished to the pattern maker, but must be provided by him in correct shapes and sizes, in addition to the pattern itself with its added core prints.

In building a pattern the workman, as before stated, must allow for **shrinkage.** He must also allow for **draft** and for **finish.**

Shrinkage. The shrinkage of cast iron when cooling in the moulds is, as has before been stated, about $\frac{1}{8}$ inch to each foot, and the manner of obtaining the exact sizes for different parts of the pattern has been explained under the head of "Rules" (page 38). For brass or bronze castings a greater allowance must be made, averaging $\frac{3}{16}$ inch to each 12 inches. Shrinkage rules for brass ($\frac{3}{16}$ inch to the foot) can be obtained, and must be used for all patterns made from brass.

Draft. After shrinkage, the second point of importance in a well-made pattern is draft. By this term is meant the bevel or taper made on all vertical parts of the pattern so that it can easily be lifted from the sand without injury to the mould. This is best illustrated as in Fig. 134, in which it will be seen that if the diameter of a pattern at *a* were to be the same as that at *b*, the latter point would drag over the whole length of the sand until it reached the former point. As the sand is held together only very lightly, this dragging would be likely to dislodge some of the particles and make it necessary to mend the mould. In order to avoid this, the diameter at *a* is made slightly greater than at *b*, so that the body of the gland is tapering, and the moment it is started out the whole surface from *a* to *b* is clear of the sand and can be removed without injury thereto. This difference in the diameters at *a* and *b* is called the *draft* of a pattern. The amount of draft depends upon the length of the part that is to be drawn out of the sand.

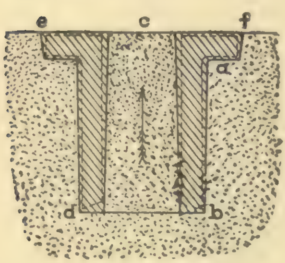


Fig. 134.

The allowance for draft varies with the pattern, and is often greater or less on different parts of the same pattern. For example, the draft on the outside of the pattern of a pulley rim 24 inches in diameter and 6 inches face, should be $\frac{1}{8}$ inch to the foot, while on the inside of the rim and on the hub of the pully it should be in the ratio of $\frac{3}{8}$ inch to the foot. The reason for this difference is that the face of the rim is often turned and finished *straight*, and for that reason the least possible amount of draft that will allow of the pattern being removed from the sand should be used; while on the inside of the rim a greater amount of draft strengthens the metal rim, which must sustain the strain and pressure of the belt. In general the draft should be from $\frac{1}{8}$ inch to $\frac{3}{8}$ inch for each 12 inches, the latter amount in all cases where the removal of the

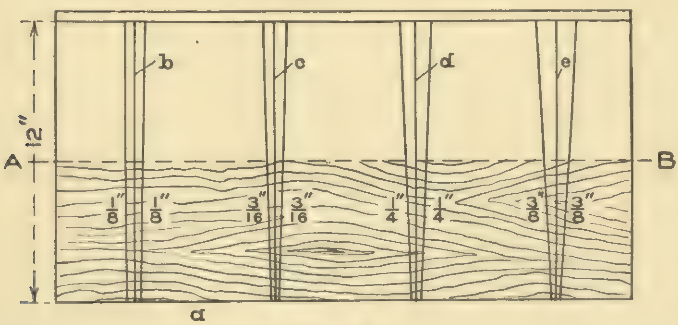


Fig. 135.

metal thus added will not greatly increase the expense of working the casting. To obtain any required amount of draft correctly, a draft template, kept with other tools and templates, will be found convenient and useful, saving much time when changing from one ratio of draft or bevel to another. It is made as follows:

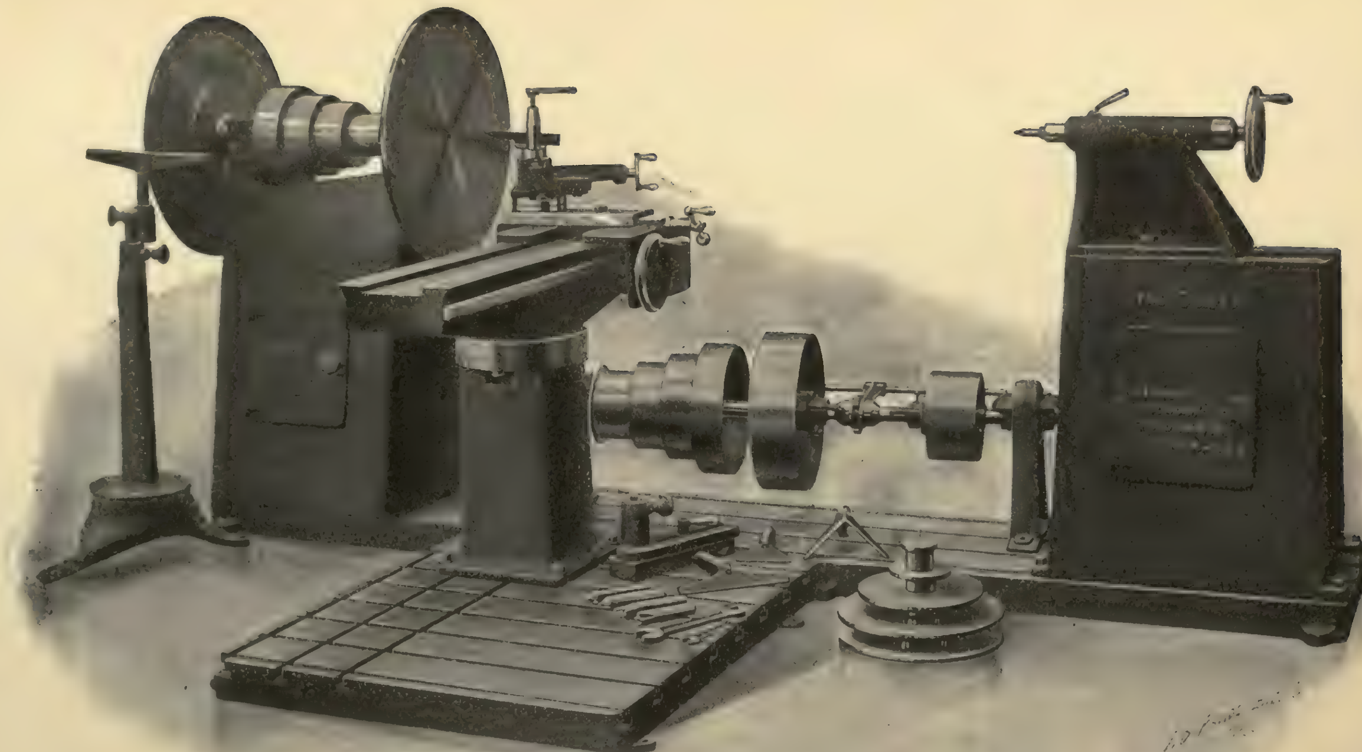
Take any straight-grained board 14 inches to 16 inches long and 12¼ inches wide, as shown in Fig. 135. Having jointed the edge *a* perfectly straight, draw the line *b* perpendicular to the edge and 12 inches long, using a square and a sharp-pointed knife (not a scratch-awl or a lead pencil). On the edge *a* carefully measure $\frac{1}{4}$ inch on each side of *b;* and at the upper extremity, with the same care, measure $\frac{3}{8}$ inch on each side of *b;* connect the last two points thus found with the first two on the edge *a*, by a sharp knife line, and the result will be a right and left slanting line, having, with reference to the perpendicular, a slant of $\frac{1}{8}$ inch to a foot. These lines should each be marked "$\frac{1}{8}$ inch," as shown in the drawing.

Now draw a second perpendicular *c*, at a distance of $1\frac{1}{2}$ inches or 2 inches from the first. On the edge of the board *a*, again carefully mark off $\frac{1}{4}$ inch on each side; at the other extreme mark off $\frac{7}{16}$ inch on each side of *c*, and again connect the latter points with the former. The result will be a taper of $\frac{3}{16}$ inch to a foot. Again repeat the process, making the taper $\frac{1}{4}$ inch, and lastly $\frac{3}{8}$ inch, to a foot. Mark the pairs of right and left-hand tapers respectively $\frac{1}{8}$ inch, $\frac{3}{16}$ inch, $\frac{1}{4}$ inch, $\frac{3}{8}$ inch, as shown. These lines having been obtained permanently, the width of the board may be cut down from $12\frac{1}{4}$ inches to 6 inches (as shown by the dotted line A B), and the board then shellaced.

To use this template, place the bevel against the edge *a* of the board, and carefully adjust the blade to the $\frac{1}{8}$ inch, $\frac{3}{16}$ inch, or other draft, right or left as may be required. It will readily be seen that whatever may be the width of the surface to which the bevel is applied, the taper or draft will be in the exact proportion of the given amount for each 12 inches.

Finish. The term *finish*, in pattern making, refers to the additional amount, after shrinkage and draft, which must be added to the pattern in places where the casting is to be planed, turned, chipped and filed, or "fitted," in the machine shop. The amount that is to be so added is, to a certain extent, though not wholly, independent of the size of the piece. For small articles whose longest dimension does not exceed three or four feet, an addition of $\frac{1}{8}$ inch to the surface to be finished is usually sufficient. For larger dimensions it may be necessary to add as much as $\frac{1}{4}$ inch or $\frac{3}{8}$ inch, but very rarely more than this. In making this allowance it is also well to bear in mind the tendency of the casting to warp in cooling. Where the thickness of the metal varies to any great extent, there is a greater liability to warp than if a uniform thickness prevails throughout the whole. Hence, in such cases, a greater allowance must be made for the finishing.

On small pieces and where the moulding is carefully done it may be possible to make as small an allowance as $\frac{1}{16}$ inch, but as a general rule sufficient metal should be put upon the casting to allow



COMBINATION PATTERN LATHE.

Oliver Machinery Company.

the cutting tool of the finishing machine to cut well below the surface so that it shall not become dulled by the sand and hard scale on the outside.

A pattern for the plain cast-iron bar illustrated in Fig. 136 will afford a good example of the allowance necessary for finish and for draft. This bar is to be finished all over, the finished sizes being 36 inches long, 1 inch wide, and 1 inch thick.

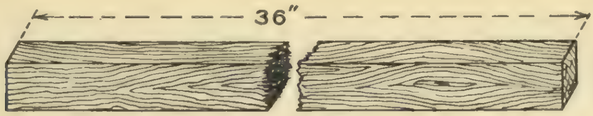


Fig. 136.

A slender bar of this length is liable to warp or bend when cooling in the mould, and for this reason the bar should have an allowance of at least $\frac{1}{8}$ inch all over for finish, thus requiring a pattern $36\frac{1}{4}$ inches long, $1\frac{1}{4}$ inches wide, and $1\frac{1}{4}$ inches thick. Moreover, to enable the moulder to remove the pattern from the sand without injury to the mould, we must add on two of the opposite sides a draft of about $\frac{1}{4}$ inch to the foot, making a cross-section through the pattern of the shape and dimensions as shown in Fig. 137.

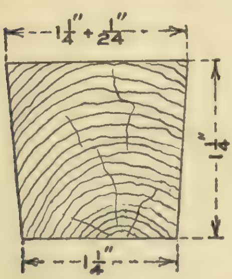


Fig. 137.

When accuracy is required in testing bars 36 inches $\times$ 1 inch $\times$ 1 inch (which are seldom finished), they are often moulded partly in the cope and partly in the drag, as shown in Fig. 138, the parting being on the line *a b*. In this position the inclination of the sides of the pattern in the mould is so great that no draft is required, the pattern being simply a square bar of wood of dimensions of 36 inches $\times$ 1 inch $\times$ 1 inch, measured with the shrinkage rule.

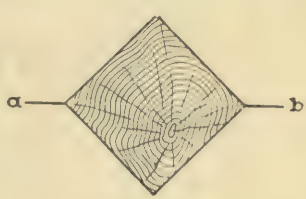
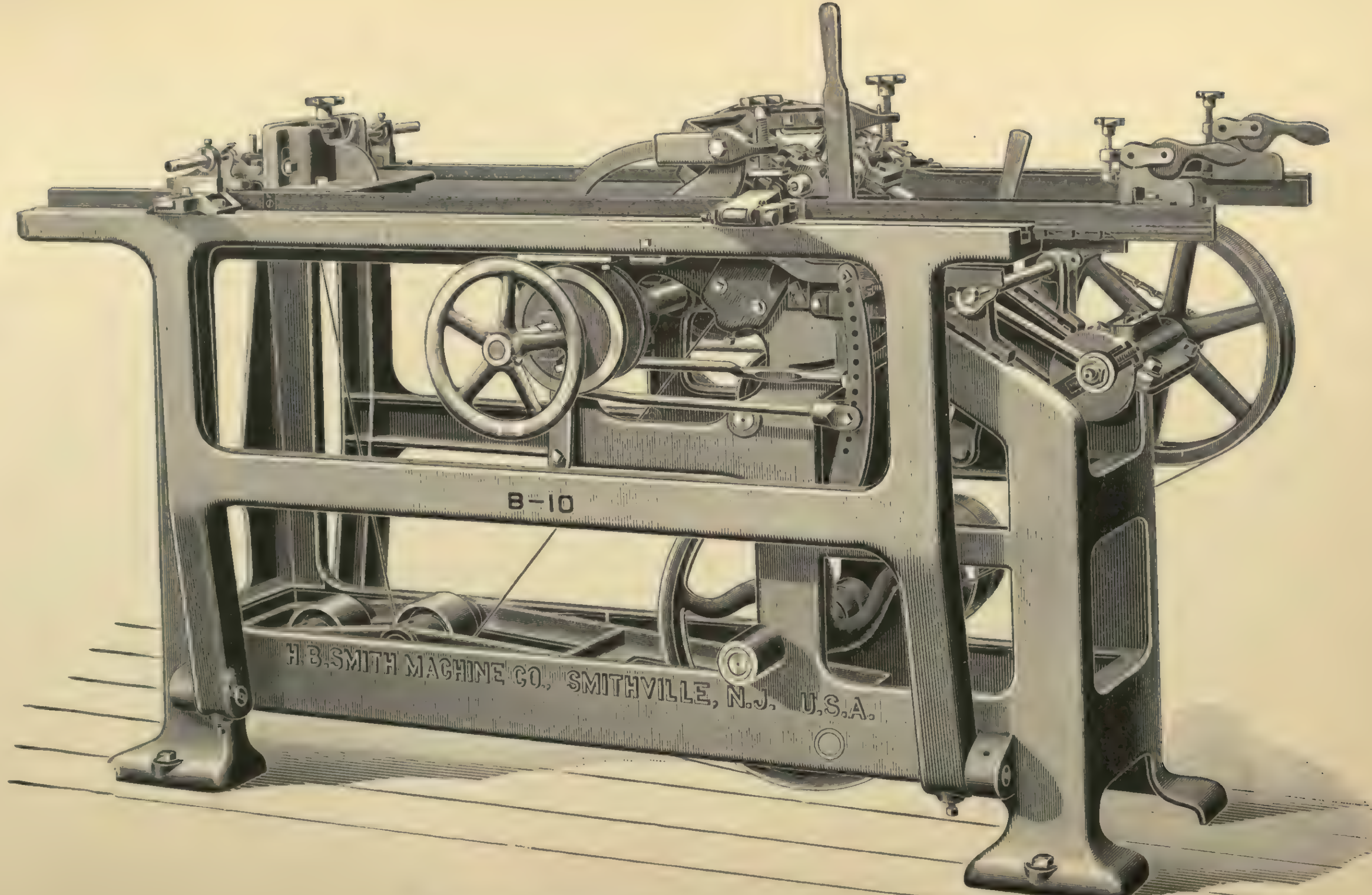


Fig. 138.



QUADRUPLE MORTISING AND BORING MACHINE.

H. B. Smith Machine Co.

PATTERN MAKING.

PART II.

SIMPLE PATTERNS.

The simplest patterns are those which are made in one piece, and which require no coring, although the castings themselves may be hollow.

The first thing which the pattern maker should decide in commencing a pattern, is the way in which it is to be removed from the sand, and where the parting line, if there is one, should be. As an example of a simple pattern of one piece made without a dry-sand core, the stuffing-box gland (shown in Fig. 134, Part I) is a good illustration. It is readily seen that if the pattern of such a gland were to be imbedded in sand, as shown, there is no reason why it could not be lifted out without disturbing any of the surrounding or the internal sand. The drawing represents the pattern with *draft* and *finish* added, the finished gland being shown by the dotted lines.

In every pattern of this kind, forming its own core, it is necessary to allow double draft on the inside, so that the pattern may be rapped and removed without injury to the green-sand core, which at best is not very stable, and which should be used only when the gland or other hollow casting is of such size as to give a large and stable core.

Except in a few special cases, it is much better to put core prints on the ends of the pattern and use a dry-sand core in place of the green-sand core illustrated above, thus avoiding the unnecessary waste of metal added by the double draft on the inside of the casting, and the expense and labor of removing it in the machine shop.

In order to give a better understanding of the methods employed in Pattern Making, the object itself will be illustrated; and when it is to be finished, the finished dimensions only will be given. If the object is not to be finished, the sizes of the completed castings will be shown. These dimensions will, in all cases, be arbitrary, and can be changed at will, if for any reason alteration is necessary. The successive steps in the construction of the pattern are given in detail so that the student may fully understand the principles involved.

The first article for consideration is the *brass bushing* flanged at one end, illustrated in Fig. 139. This bushing is to be finished *all over*, and as the casting is small, $\frac{1}{16}$ inch will be sufficient for out-

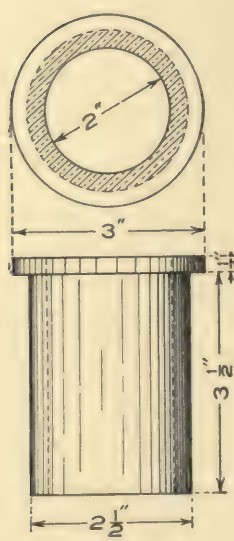


Fig. 139.

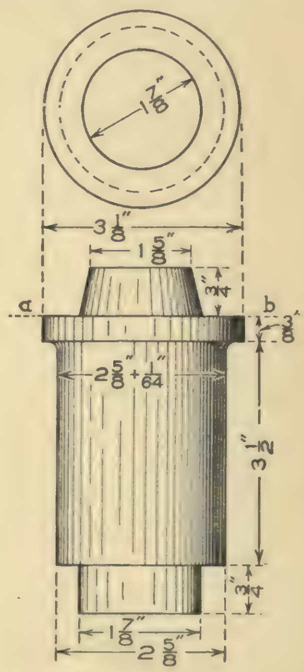


Fig. 140.

side finish and the same for turning out the inside. On examining it with regard to moulding, we find that if moulded on end with the flange up and on the parting line of the flask it can be readily removed from the mould.

The draft in this case should be $\frac{1}{8}$ inch in 12 inches or a little less; and each core print, because the pattern is very short, need not be more than $\frac{3}{4}$ inch long. Having the finished sizes given (Fig. 139), and having decided on the amount of draft and finish, the pattern will be as represented by Fig. 140, and in the case of this simple pattern, as in all others, a full size drawing, or sketch, giving all the dimensions of the pattern, should be made by the pattern maker before beginning work on the pattern. This is good practice, and if carried out many mistakes and much loss of time will be avoided.


Fig. 141.

The lower core print should have the same proportion of draft as the body of the pattern, but the upper core print is given the excessive draft of $\frac{1}{8}$ inch to its length so that the cope can be easily lifted off and returned again over the tapering end of the dry-sand core without injury to the mould; the parting of drag and cope being on the line *a b*. This pattern may be turned from a solid block of wood, but if durability is desired the block should be glued up from 4 pieces of $\frac{7}{8}$-inch pine, care being taken to reverse the annular rings or yearly growth of the wood, as shown in Fig. 141.

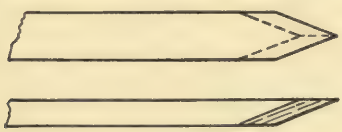


Fig. 142.

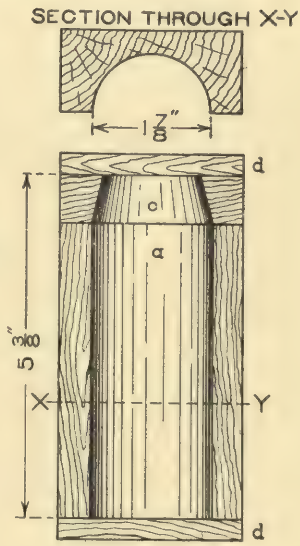


Fig. 143.

Place the block in the lathe and with the gouge turn to a cylindrical form of slightly greater diameter than the largest diameter of the pattern, say $3\frac{3}{16}$ inch. All finishing should be done by the use of scraping tools. For the body of the pattern, a firmer chisel 1 inch wide is a good tool, but the cutting edge must be ground and sharpened slightly rounding, as described for plane irons; otherwise the corners of the tool are liable to catch and form grooves on the surface.

For smoothing and finishing the ends of the pattern and flange, a diamond-pointed scraping tool, Fig. 142, is preferred to all others. The core box for this pattern is shown in Fig. 143, which is representative of the half box used for all symmetrical cores. In this box, two semicircular or half cores are made, which, after being dried, are pasted together, forming the cylindrical core required. For the part *a* of the core box, a block of slightly greater length ($\frac{1}{2}$ inch or 1 inch) is first planed up to the exact size. A center line *b*, Fig. 144, is drawn with the marking gauge parallel to one of the edges, and also extends across each end of the block.

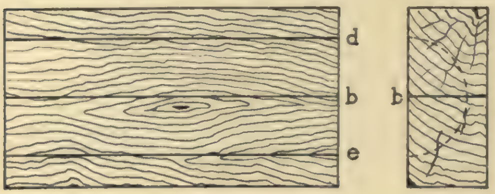


Fig. 144.

From this center line, at a distance of $\frac{15}{16}$ inch on each side, the lines *d* and *e* are also drawn. Then with a second block, or strip of wood placed against the face of the block and flush with the end, the two pieces are clamped together in the bench vise, as shown in Fig. 145. Now with the dividers adjusted to $\frac{15}{16}$ inch, describe on each end of the block the semicircle which will connect the lines *d* and *e* on the ends of the block. This wood may be removed rapidly with a gouge and mallet, smoothed with a round plane of proper size and curve, and finished by sand paper rolled on a cylindrical block having a diameter $\frac{3}{16}$ inch less than the width of the required box.

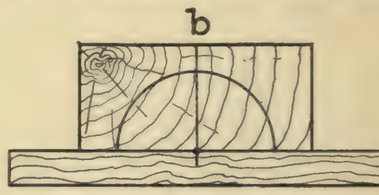


Fig. 145.

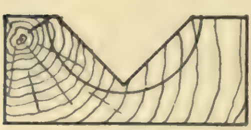


Fig. 146.

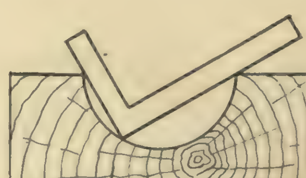


Fig. 146*a*.

Another method frequently used for small boxes, is to work out the center of the curve with a rabbet plane, forming a right-angled opening, as shown in Fig. 146, the remaining wood being removed with the round plane and finished with the cylinder and sand paper as before.

As the work progresses, the accuracy of the curve is tested by means of a try square, or other 90° angle, as shown in Fig. 146a.

The tapered end of the box *c* (Fig. 143) is turned from a block of wood, screwed to the face plate of the lathe as shown in Fig. 147. After the hole is turned to the required depth, ¾ inch, and to the required size, 1⅞ inches on the outside, and 1⅝ inches at the bottom, it is removed from the face plate and the piece *c* is cut out, as shown by the dotted lines in Fig. 147. This piece *c* is glued and nailed to the end of *a*. The two ends of the box are now given a slight draft, (¼ inch in 12 inches) to allow the half core to leave the box easily. The end strips *d* and *d* (Fig. 143) are then nailed on and the box is complete.

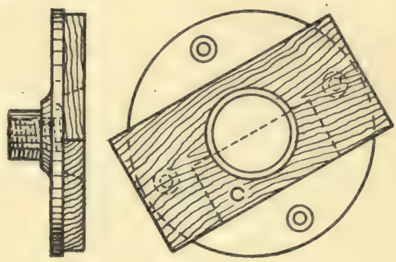


Fig. 147.

FINISHING PATTERNS.

Having completed the pattern and its core box, the surface of the wood must be covered with some material which will render it hard, smooth, and impervious to the moisture in the sand, and at the same time make it easier to be withdrawn from the mould. Pure grain-alcohol shellac-varnish is the best for this purpose. All cheap substitutes, such as wood-alcohol shellac, or copal varnishes should be avoided. They become flaky and scale off, and do not stand the exposure and moisture. Pattern makers generally make their own shellac varnish, buying only the best quality of shellac gum, and using 95 per cent proof alcohol. The proportions are three pounds of gum to one gallon of alcohol. The gum is put in a wide-mouthed bottle, or earthen jar, and the alcohol poured over it, and if well stirred three or four times during the day will (if the alcohol is of the best,) give a smooth, clear, orange-colored varnish ready for use.

A good grade of "white grain-alcohol shellac" may be made from bleached gum, or can be bought from the dealers, but it dries more slowly and does not produce so hard a surface as the orange shellac.

As the alcohol in shellac-varnish evaporates very rapidly, the brush should be kept in a vessel which is closed and air tight. A short bottle having a mouth wide enough to admit the brush is best for this purpose. A one-inch, flat, double-thickness, fitch-hair brush is good for general work. Do not use a cork, but turn a wooden cap for the bottle, such as is shown in Fig. 148. The shoulder at *a* may be $\frac{3}{16}$ inch to $\frac{1}{4}$ inch long, but must be at least $\frac{1}{4}$ inch less in diameter than the inside of the mouth of the bottle. Otherwise the shellac will cement it to the glass so that it cannot be removed. Its only object is to keep the cap nearly central on the bottle. The handle of the brush must be tightly fitted into a hole through the center of the cap and fastened with a screw or brad; allowing the brush to reach within one-half inch of the bottom of the bottle. Keep the bottle one-third to one-half full of shellac and use the brush with the cap on the handle. The shellac will make a tight joint between the bottle and the cap, and if the proper amount of shellac is kept in the bottle, the brush will always remain soft.

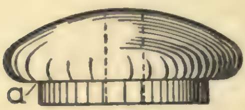


Fig. 148.

For small patterns, such as the bushing described, the small quantity of shellac needed can be used directly from the bottle. For large work however, an earthern-ware cup or mug should be used, but the shellac left over should always be returned to the vessel in which it is kept.

Shellac varnish should never be kept in a metallic can or cup, as the oxidation of the metal will discolor the varnish.

Having given a perfectly smooth surface to the pattern and core box by the use of very fine sand-paper, (No. 0) apply the first coat of shellac. This first coat will raise the grain and roughen the surface of the wood, which, after the shellac is perfectly dry, must be sand-papered a second time until smooth. Now apply a second coat. Should there still be roughness, a second sand-papering will be necessary. At least three coats of shellac should be used. If there is much end wood exposed on any of the surfaces of the pattern, a fourth coat may be necessary on these parts.

As regards the color in which patterns are finished there are different rules in different shops. The general rule, however, is to leave all patterns for brass or bronze, in the natural color of the wood, and shellac the core prints red. If the pattern is intended for moulding cast iron, the body of the pattern is made black and the core prints red. The parts of the core box in which the core is to be formed are also colored red and the outside of the core box black. The black color is produced by mixing lamp black with the shellac varnish, and the red color by mixing vermillion (Chinese is the best) with the shellac. The vermillion is heavy and will settle, hence it must be stirred or well shaken before using. The best method is to first use two coats of the natural colored shellac (orange or white) on all surfaces of the pattern, core prints and core box, then apply the black or red for the last coat only.

As the pattern already described is for a brass bushing, the body should be left the natural color of the pine, and the core prints on the pattern and the inside of the core box colored red.

The outside of the core box may be left the natural color or made black, as preferred. The outside of the core box, having no part in the formation of the core, is not necessarily so well and smoothly finished as the inside.

All nail holes or any defects in the wood should be filled with beeswax applied with the warm blade of a knife, or narrow chisel, warmed by holding in hot water. The beeswax should always be used after the first coat of shellac has been applied, as it will then hold better. The sand-papering of the pattern, after the first coat. will smooth the wax and bring it even with the surface of the wood The time required for a coat of shellac to dry is from eight to twelve hours, depending upon how heavily it may have been applied, even though to the touch the surface may seem dry in one or two hours.

If a hard, *durable* surface is required on the pattern, twelve, or better, twenty-four hours must be given between each coat. The roughness will then sand-paper off as a dry powder without gumming the sand-paper, and leave a hard, smooth surface for the succeeding coat of shellac.

The second casting to which attention is called, is the *brass bearing* represented in Fig. 149, which is to be finished all over. On examining the drawing, first with regard to removing the pattern from the sand, we find that it must be moulded on its side, and that the moulder may not lose time in cutting away the sand (see Figs. 113 and 114, Part I) the pattern must be *parted*, or made in two halves.

For finish on this small pattern $\frac{1}{16}$ inch will be sufficient, and draft will be required only on the ends of the pattern, and on the ends of the core prints, which in this case, should be not less than 1 inch long. This is necessary, because the core-print moulds must sustain the weight of the dry-sand core.

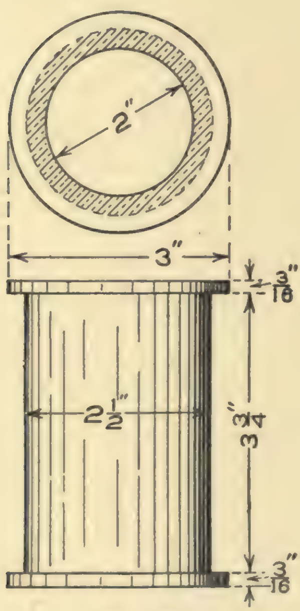


Fig. 149.

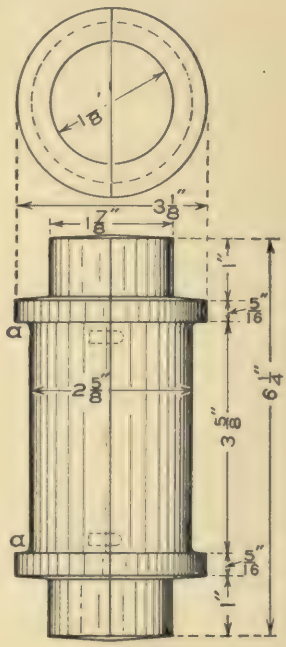


Fig. 150.

The pattern for this casting is represented by Fig. 150, in which it is seen that, unlike Fig. 140, the body and core prints are perfectly straight, a slight draft $\frac{3}{16}$ inch to 12 inches being given to the ends of the pattern and to the ends of the core prints only. A slight curve of $\frac{1}{16}$ inch radius should also be made at the intersection of the body of the pattern, and the inside of the flange at *a*, *a*.

The wood in being prepared for this pattern should be cut 2½ inches longer than the finished pattern. The dimensions of the two halves would each be $1\frac{3}{4} \times 3\frac{3}{8} \times 8\frac{3}{4}$ inches. Having fitted the two insides accurately together and dressed one edge of each straight and at right angles to its face side, with the marking gauge, draw a center line on each, not only on the face but also across each of the two ends, Fig. 151. Across the center of each piece draw, with a sharp-pointed knife and try square, a second line at right angles to the first and at equal distances from each end of the block. With dividers adjusted to $1\frac{7}{8}$ inches, place one leg at the intersection of the two lines, and on the gauge line mark two dots, each $1\frac{7}{8}$ inches from the center line. These dot are the centers for the dowels which are to connect the two halves of the pattern after it is finished. Bore the holes in each piece $\frac{1}{2}$ inch deep with a $\frac{5}{16}$ inch auger bit, and cut the dowel pins only $\frac{3}{4}$ inch long, gluing them into the holes of one piece and giving a projection of $\frac{1}{4}$ inch to fit in the holes of the second half of the pattern. Although the dowels are glued into the first half they must fit easily, but not loosely, in the second, and should be rounded on the ends or made cone shaped, as in Fig. 152.

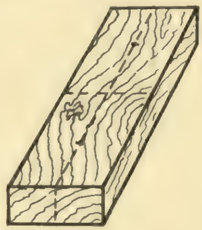


Fig. 151.

Having fitted and prepared the two blocks with their dowel pins, carefully glue them together using only a narrow strip of

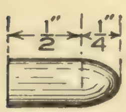


Fig. 152.

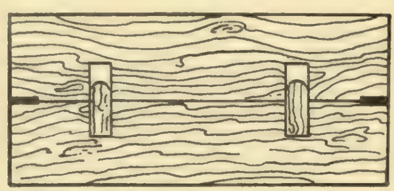


Fig. 153.

glue $\frac{1}{2}$ inch wide on each end of the block and clamping the two together with a hand screw on each end. When the pressure of the hand screw is applied, the glue will spread inward to $\frac{3}{4}$ inch or 1 inch. Great care must be taken not to use too great a quantity of glue, or it will spread in far enough to bind the two halves of the pattern together so that they cannot be separated when turned and finished. The blocks should remain in the hand screws, after being glued, from four to six hours, depending on the temperature of the room in which the gluing is done. Our pattern block is now ready for the lathe and will be as represented in Fig. 153, which is a longitudinal section through the dowel pins.

When centering for the lathe centers, great care must be taken to mark the centers exactly at the intersection of the center-gauge lines on the ends of the blocks and the glued joint of the two pieces. The hard glue will force the lathe center to one side of the connecting joint unless a center dot or hole is first made with an awl in the exact position required. As in the case of the pattern in Fig. 140, the block is roughly turned to dimensions, all of which are a little larger than the finished pattern, by using the ordinary turners' gouges, but the final turning and finishing to exact sizes must in all cases be made with scraping tools, as described for the pattern of the *brass bushing*.

When marking off the pattern on the rounded cylinder in the lathe, care must be taken to locate the pattern in the exact center of the block, so that the dowel pins may be equally distant from each end and from the center of the pattern. Fig. 154 shows the pattern as ready to be taken from the lathe. The core print ends should be cut down to $\frac{3}{4}$ inch at each end, and finally cut off with a saw, and the ends finished with file and sand paper after removing from the lathe, when, as will be seen, the glued end having been cut off, the two halves of the pattern will separate clean and free from glue, and the dowel pins will always bring them into accurate alignment when used by the moulder in the foundry. Before removing the turned pattern from the lathe, it should be smoothed and finished with sand paper, but care must be taken not to allow the sand paper to come in contact with the sharp corners and angles of the pattern, or they will be rounded off and the work ruined. For pine, only the finest paper, No. $\frac{1}{2}$ and No. 0 should be used on lathe work, and the paper must not be held in one position on the revolving work but must be kept moving laterally, that is, from side to side, to avoid cutting depressions in the surface.

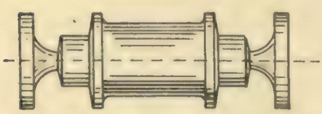


Fig. 154.

When the scraping tools are kept sharp so that they will cut freely and without pressure, a light touch of sand paper only will be required.

In the construction of this pattern, it may be made of two blocks of $1\frac{3}{4}$-inch stock as described; but the tendency of the two halves will be to become rounding on the parting line as shown by the dotted lines *c d* and *e f*, Fig. 155. This is caused by the removal of considerable wood in the process of turning, at the angles *a a a a* thus exposing fresh surfaces which are farther removed from the original surfaces of the plank, than the surfaces on the line of parting. The exposure of these deep, inside fibers of the wood will cause a shrinkage of the pores and draw the pattern more or less, according to the position of the annular growths, and also to the more or less thorough seasoning of the wood, in the direction indicated. If the pattern is intended for temporary use only, it may be constructed as above, but if durability and permanence of shape are required, the two blocks should each be glued up out of thinner stock with the annular growths carefully reversed, as

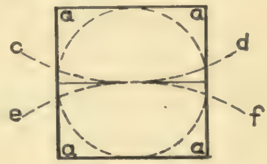


Fig. 155.

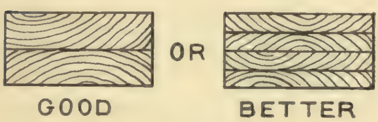


Fig. 156.

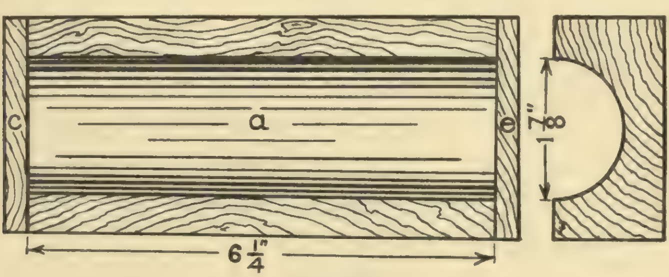


Fig. 157.

shown in Fig. 156. This is done not only because thin plank is more evenly and better seasoned, but because in gluing, the tendency of the pieces to warp or spring is counteracted each by the other, and in addition the gluing of several thin pieces together stiffens and makes the resulting piece much firmer and stronger than a large block or piece of the same size obtained without gluing.

The core for this pattern, being straight from end to end, and cylindrical, only a half core box is required, as shown in Fig. 157. After being laid off and worked out in the same manner as described for the core box, Figs. 143 and 144, cut the ends of *a* with draft of $\frac{1}{4}$ inch in 12 inches, and glue and nail on the ends *c* and *e*, which may be $\frac{3}{8}$ inch to $\frac{1}{2}$ inch in thickness.

Shellac and finish as described for pattern, Fig. 140, giving first two coats of orange or white shellac, and for the last coat on core prints of the pattern and the inside of the core box *a* use the red, the body of the pattern being left natural color (with three coats) and the outside of the core box either natural or black.

GLUING.

As the use of glue enters largely into the construction of all patterns, some instruction as to its selection and the manner of using will be necessary. When building up patterns, the connections should in all cases be made by gluing. Nails should never be used except when they can be so placed as to be entirely removed from all danger of contact with the tools used in turning and shaping the pattern, and when so employed should be used in conjunction with glue. The only advantage in their use is the hastening of the work, because they take the place of hand screws or clamps while the glue is drying.

The use of nails, however, is always unsatisfactory, for when the point is passing through the upper piece, small thin slivers are broken from the under surface, which have a tendency to separate the two surfaces instead of exerting the required pressure as when hand screws are used.

For pattern work select only the very best quality of cabinet-makers' glue, or better still, the best quality of white glue. This white glue can always be had in two forms, first, white glue, *clear*, and second, white glue *opaque*. The first is the glue without the addition of any foreign substance. The second looks much whiter than the first, because of the addition of whiting, or other mineral, to the glue. This addition does not in any way lessen the adhesive qualities of the glue; on the other hand, it sets more readily and dries more quickly, but for this very reason, it is harder to use on large surfaces, as the first brushing on one part of the work will begin to set before the entire surface can be covered. For all small or moderate-sized work, however, the opaque, white glue is to be preferred.

Good glue will keep in a dry room of any temperature for an indefinite length of time, but when cooked in the glue-pot it deteriorates very rapidly. Each successive reheating and boiling lessens its adhesive qualities, hence it should always be used *fresh* or nearly so. A greater quantity of glue than is likely to be used in two or three days should not be cooked at one time.

The cooking and preparing must be done in the regular glue-pot, made for the purpose, and sold in all hardware stores. No rule can be given for the relative quantities of glue and water to be used. Some glues, especially the cheaper grades, require much less water than the better and finer qualities. As a general rule however, pack the glue firmly in the pot and add sufficient cold water to cover it. Fill the outside kettle with cold water and boil until thoroughly cooked, so that it will run smooth and clear from the brush or paddle. It should run freely without returning and gathering in bunches or clots at the end of the paddle, but must not be so thin as to be weak and watery.

If the glue is too thick, no amount of pressure will bring the two glued surfaces in close contact, and if too thin there is danger that the joint will not hold. Always use cold water for cooking and dissolving fresh glue. Hot or boiling water will make the glue *stringy* and will require a much longer time to cook to an even and smooth consistency. Great care should also be taken to keep the outside kettle, which surrounds the glue-pot proper, full of water. If allowed to *boil dry* the glue in the inner pot will be scorched, or burned, and will then be entirely useless. It must then be thrown out, the pot washed or boiled out clean, and fresh glue again cooked. The hot water in the outside kettle should in all cases be used for thinning the glue to the required consistency. Cold water chills the glue and necessitates reheating. In cold weather the precaution must be taken, unless the room is warm and entirely free from drafts, to heat the pieces of wood before applying the glue, else the latter may be chilled and fail to set. The time required for well-made joints to dry so that the hand-screws can be removed is from four to six hours.

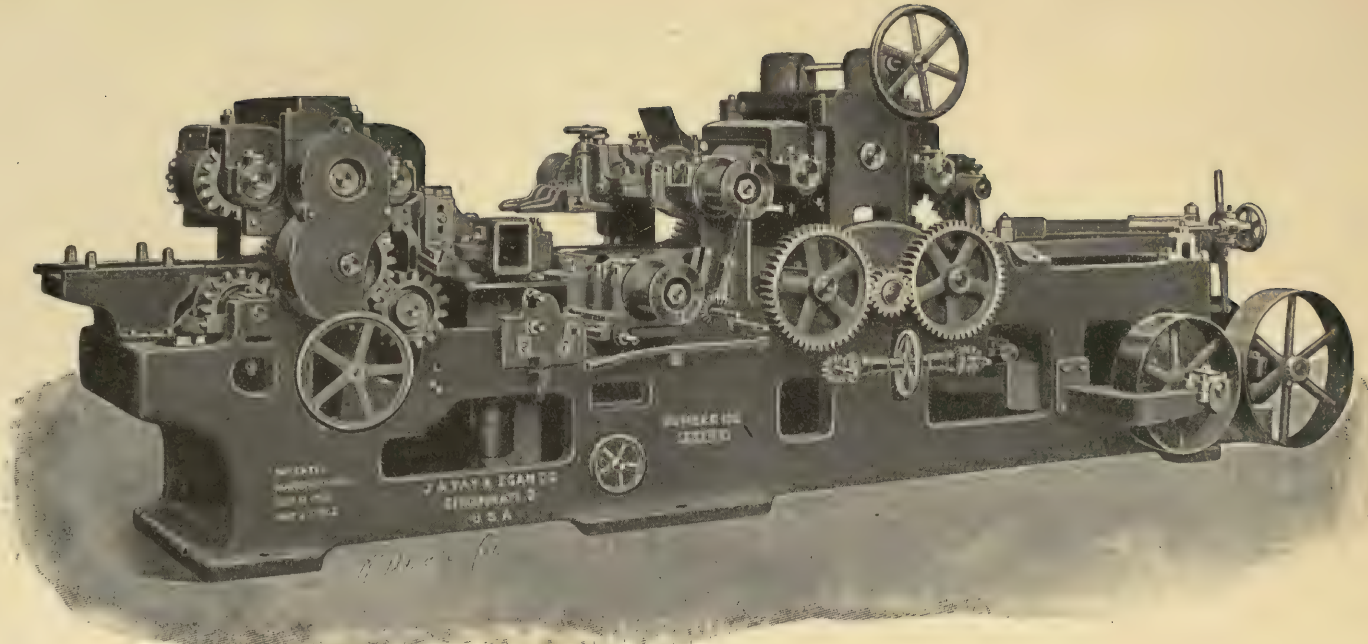
Sometimes a difficulty will arise in the case of large surfaces on thin material. When the glue is applied it moistens and expands the surface upon which it is placed, causing the edges to curl up and pull away from the adjoining piece which has a tendency to move in the opposite direction. In such cases *never* moisten the back of the thin pieces with water from the outside kettle, as is sometimes directed, but work quickly, spreading the glue rapidly and then place between two thick, stiff pieces of board, previously dressed true, prepared and heated for the purpose. Use as many hand-screws as can be conveniently placed on the work, and allow it to remain in these clamps until all moisture from the glue is absorbed by the two outside, heated boards. Twenty-four, or better forty-eight, hours should be given to this process if possible.

All such gluing of thin pieces should in every case be done first and allowed to dry while the other parts of the pattern are being constructed. Under no circumstances use water on any surface of seasoned wood. The reseasoning or drying out of such water will invariably distort, curl, and warp the pieces so treated after being glued together. Even the water contained in the glue is objectionable, while unavoidable, and can be most satisfactorily removed only as directed above.

In all cases where end wood is to be glued, or where the grain of the wood runs diagonally to the plane of the joint so as to present the open end wood pores for the glue, this end wood, or partially end wood joints, should be first "*sized*" with thin glue, (glue about half the thickness of that used for gluing,) and allowed to dry. This will raise the grain and roughen the surface of the joint, which, when dry, must be lightly and carefully scraped off with a sharp chisel, when it will be found that the open pores of the wood are filled with dried glue. The joint may now be glued, and the glue will hold as in ordinary jointing.

HAND SCREWS.

The hand screws, illustrated in Fig. 81, enter so largely into all gluing for pattern work, that some description of their con-



FLOORING MACHINE.

J. A. Fay and Egan Co.

struction and the manner of using is necessary here. The four parts of each hand screw consist of two *jaws* and two *spindles*. When using, the *jaws* must in every case be kept parallel. This is done by the adjustment of the middle or central spindle. The clamping is in all cases done by the outside or end spindle, the middle or adjusting spindle serving as a fulcrum for the jaws; the leverage and pressure being obtained by the end spindle. When clamping broad surfaces, care must be taken to see that the pressure of the jaws on the work being glued is the same at the points and at the back part of the applied portion of the jaws.

This can be easily changed at will, by slightly loosening or tightening the middle spindle, which, as before stated, is the adjusting spindle and fulcrum, and not used for clamping. After adjusting the jaws parallel and to even pressure on all their length as applied to the work, screw up and tighten the end spindle to the utmost pressure which the jaws will bear, and again examine the clamp and the work to see if the jaws are parallel and the pressure even.

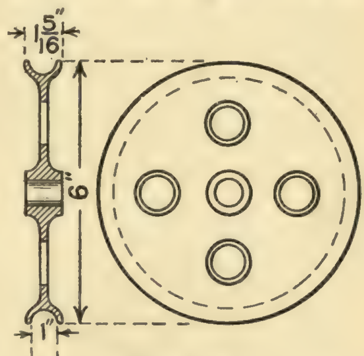


Fig. 158.

If not, loosen the end spindle and readjust the middle spindle by opening or closing as the case may require. To open and close the hand-screws for larger or smaller work, *do not* screw or unscrew *one* spindle at a time. Instead, grip the handle of the *middle* spindle in the left hand, and the handle of the end spindle in the right hand. Hold the hand screw at arms length and whirl it from or toward you as may be needed for closing or opening the jaws In this way the spindles will each be kept in its proper relative position, and the jaws will, at all distances, remain parallel.

BUILT UP PATTERNS.

A good example of the manner in which patterns are built and glued up is shown in the construction of the pattern for the 6-inch sheave pulley shown in Fig. 158.

The groove is a semicircle 1 inch wide, and the rim containing the groove is connected with the hub by a solid web $\frac{1}{4}$ inch in thickness, and having four or six holes, each 1 inch in diameter, this web taking the place of arms. If there is to be no *finish* on the sheave, as is usual, the only allowance to be made on the pattern, *which must be parted*, will be for shrinkage and for draft.

A cross-section through the finished pattern for this casting is shown in Fig. 159.

In all large patterns of this kind, the web is first glued up

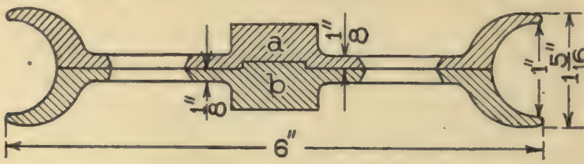


Fig. 159.

in sectors, six, eight or more in number, according to the size of the sheave (see Fig. 160). The sectors are fitted by hand or on the trimmer, the ends are glue-sized, and when the sizing is dry the joints are carefully scraped smooth, and the whole glued together. After drying for four or five hours, it is sawed to a circle of $\frac{1}{2}$-inch greater diameter than the finished pattern, and the block for the

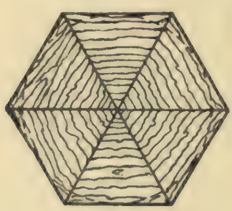


Fig. 160.

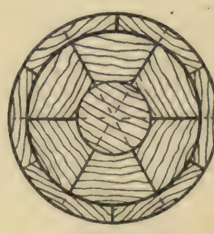


Fig. 161.

hub is glued over the center. Six segments to form the outer rim are glued around on the outer edge, care being taken to *break joints* as shown in Fig. 161. If the groove is to be large, the six segments should be of half the thickness only, and a second set of segments of like thickness glued over the first, *breaking joints* not only with the first set, but also with sectors of the web.

In other words, in all glued-up rims, no two joints should be directly over each other. All joints must be so *broken* and so distributed as to give the greatest possible strength to the rim. In the present case, our pattern is so small that it is only necessary to use a thin board, ¼ inch in thickness for each half of the web. After sawing to 6½ inches in diameter, ½ inch for turning, a block ½ inch in thickness is glued on the center of each to form the hub; and six segments 1¼ inches wide and ½ inch in thickness, are glued around on the outer surface of each to form the rim and groove, as shown in Fig. 162.

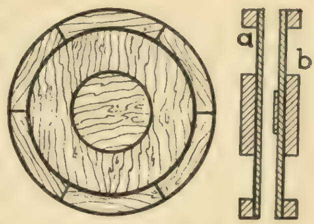


Fig. 162.

Care must be taken to place the segments so that the grain of the web will be crossed by two of the segments as shown in the drawings.

On the second half *b* of the pattern, a thin circular block ¼ inch in thickness is glued on the inside opposite to the hub block, to form the projection (⅛ inch) which will keep the two halves of the pattern in alignment, as shown in the cross-sectional drawing in Fig. 159. Having glued up the stock as described, and as shown in Fig. 162, the outside must be planed to a level surface, or so that the six segments forming the rim and the center hub block will be in the same plane.

The half pattern is now screwed on the screw chuck of the lathe as illustrated in Fig. 163, and the inside, or the parting face *c*, is turned perfectly straight and true. The edge is turned down to 6 inches in diameter, and the quartered circle shown by the dotted lines is carefully shaped. A template, made as shown at *d*, will assist greatly at this stage of the work. A recess is turned at the center, and in the face of *a*, Fig. 159, 1½ inches in diameter and ⅛ inch deep, to receive the corresponding projection on the half pattern *b* which is to keep the two halves in alignment.

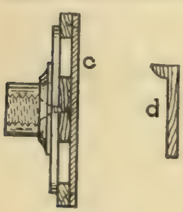


Fig. 163.

The half pattern *a*, is now removed from the screw chuck, and the second half *b* is screwed on and turned in the same manner except that the central projection is carefully turned to fit in the recess in *a*.

Before removing *b* from the chuck, test by trying the second half *a*, and change *b* until a perfect fit is obtained between the two halves, not only in the central recess and projection, but also in the two curves which form the semicircular groove of the rim. A cross-section of the pattern at this stage of construction is shown in Fig. 164.

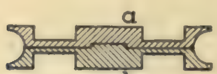


Fig. 164.

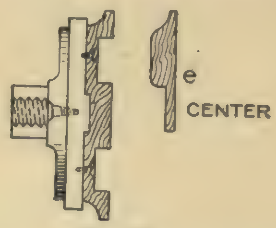


Fig. 165.

A disc or chuck of wood $5\frac{1}{2}$ inches in diameter is now screwed to the iron face-plate, or the screw chuck, and turned off true on the face with a projection $\frac{1}{8}$ inch high which will fit into the recess in the middle of the parting face of *a*. This projection will center the half pattern *a* on the face plate, and it can be held in position by two or four short wood screws driven through the web into the wooden chuck as shown in Fig. 165.

Care must be taken to place the screws in such a position that the screw holes will be cut or bored out when making the four or six openings 1 inch in diameter in the finished web of the pulley.

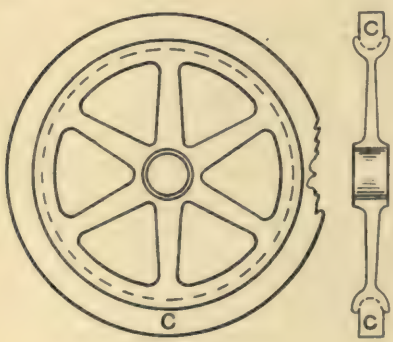


Fig. 166*a*.

The screws must be small and slender and the heads well countersunk out of reach of the turning tools. The face of the half pattern is now turned to the required shape, the template shown at *e* in Fig. 165, being used for the purpose. Having finished with fine sandpaper, remove the half pattern, and turn off the projection on the center of the wooden chuck; turn a recess instead to receive the projection on *b*, and proceed with this second half as with the first. If the wood has been well seasoned, and the work carefully done a perfect 6-inch sheave pulley pattern will be obtained, such as is shown in Fig. 159.

The pattern for a sheave pulley has been explained because it embraces so many profitable points and conditions, not only in gluing and building up, but especially in chucking and turning, all of which must be done with great care and accuracy.

The 1-inch holes in the web are bored out with a 1-inch *center bit*, which, when well sharpened, will not split or splinter the thin webs of the two halves of the pattern, if care is taken to reverse the bore from the opposite side when the point of the center bit comes through. The holes should be given a slight draft as shown in Fig. 159, with a small half-round cabinet file. When very large sheave pulleys, having arms, are to be made, such as are common for power transmission by rope or cable, the patterns are not halved but are made in one piece and the groove is *cored* around the rim. Such a pattern is illustrated in Fig. 166*a*, with a wide core print *c c* extending entirely around the periphery of the pattern.

Fig. 166*b*.

A segmental core box is made for one sixth or one eighth the circumference of the wheel, as shown in Fig. 166 *b*, and here again only half of the core box for a full core is needed. When coring the rim as above, the core print must be made wide, at least two to three times the depth of the groove, so that the core may rest firmly and remain in position without tilting while the metal is being poured into the mould.

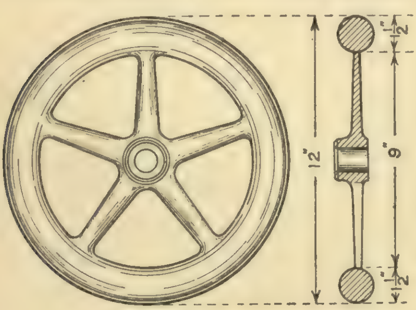


Fig. 167.

The 12-inch hand wheel, Fig. 167, with five arms and a round rim finished to $1\frac{1}{2}$ inches in diameter, will also serve as a good illustration of pattern construction. On the rim of the pattern, $\frac{1}{16}$ inch over all its surface must be allowed for *finish*, making the diameter of the rim of the pattern $1\frac{5}{8}$ inches, and the outside diameter of the pattern $12\frac{1}{8}$ inches, while the inside diameter of the rim will be $8\frac{7}{8}$ inches.

The rims of such patterns are usually turned in two halves. A wooden chuck, in this case a plain board $12\frac{3}{4}$ inches in diameter, and $\frac{7}{8}$ inch to $1\frac{1}{8}$ inches in thickness, is screwed to the iron face-plate of the lathe, and turned true on the face and on the edge to $12\frac{1}{2}$ inches in diameter. Ten blocks $2\frac{1}{2}$ inches long, 2 inches wide, and $\frac{3}{4}$ inch in thickness are glued radially at equal distances around the face of the chuck as in Fig. 168. These blocks are turned even with the edge of the chuck, and the faces are also turned off true and straight so as to form a joint with the first row of rim segments.

The segments, ten in number, five for each layer, are sawed from a $\frac{1}{2}$-inch board, and should be 2 inches wide.

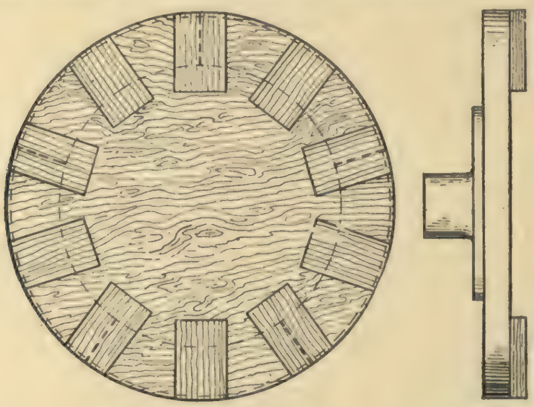


Fig. 168.

Five of these are carefully fitted and glued to the face of the blocks, as shown by the dotted lines in the drawing; and when the glue is dry the chuck is returned to the lathe, and the face of the segments turned flat and true to receive the second row, which is fitted and glued to the first.

Small hand screws must be used, three on each segment, to press the first layer to the blocks, and again to press the second layer to the first. The joints of the second layer must be over the middle of the alternate blocks from the joints of the first, so as to break joints with the first. When the glue is dry, place the chuck in the lathe, and turn the half rim thus constructed to a true semicircle with an outside diameter of $12\frac{1}{8}$ inches and an inside diameter of $8\frac{7}{8}$ inches, using a semicircular template of sheet zinc or copper to test by while turning.

When turned and sand-papered, cut from the block of the chuck by using a $\frac{1}{8}$-inch parting or cutting-off tool, care being taken to cut close to the segments forming the half rim. Turn off the face of the blocks on the chuck true and straight a second time, and construct and turn the second half of the rim in the same way as described for the first; but great care must be taken to make the two diameters, outside and inside, of each half exactly alike, otherwise the work on one half will be lost. As it is difficult to hold these two half rims for planing and fitting together, a concave and semicircular groove turned in the face of a second board, or chuck, in which they can be laid while being planed or fitted, will be found useful.

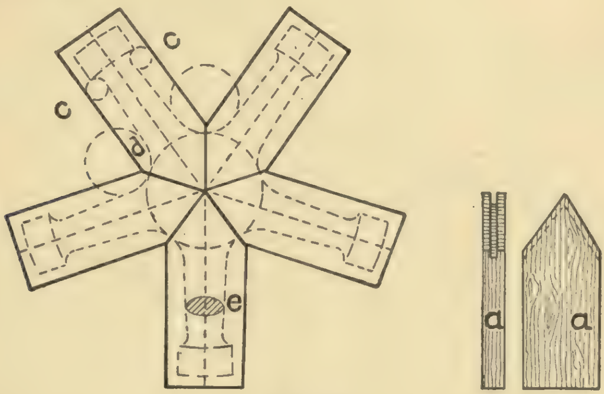


Fig. 169.

In all rim work of this kind the circular segments should be cut lengthwise with the grain of the wood, the object being in this construction, to do away, as much as possible, with all end wood.

While waiting for the separate layers of glued segments to dry, the arms should be made so as to be ready for the two half rims when completed.

The arms in this case should be made $\frac{5}{8}$ inch in thickness at the hub and $\frac{1}{2}$ inch in thickness where they enter the rim of the wheel. The construction is as shown in Fig. 169.

Five pieces, each $5\frac{3}{4}$ inches long, $2\frac{1}{8}$ inches wide, and $\frac{5}{8}$ inch in thickness are necessary. After being carefully fitted on the trimmer, a saw kerf $\frac{5}{16}$ inch deep is cut in each joint (*a*, Fig. 169), into which a thin tongue of wood is inserted and glued, the tongues serving as tenons to hold the arms together. After fitting, and before grooving with saw kerf, the joints must be glue-sized and, when dry, carefully scraped smooth with a sharp chisel.

The grain of the wood in the tongues must run at right angles to or crosswise of the joint to insure the greatest strength.

When glued together and dry, from the center or intersection of the five pieces, mark with dividers set to a radius of $5\frac{1}{4}$ inches, and cut off the ends of the arms so that they will project each half-way into the rim.

From the same center describe a circle $3\frac{1}{8}$ inches in diameter, forming the web of the arms; and from this $3\frac{1}{8}$-inch circle, taper the arms to $\frac{1}{2}$ inch in thickness at the ends, care being taken to plane the same amount from each side and to dress the arms evenly so that they will revolve in the same plane. This being done, from the center describe arcs on the outer ends of the arms, with a radius of $4\frac{3}{8}$ inches ($8\frac{3}{4}$ inches diameter, which is $\frac{1}{8}$ inch less than the

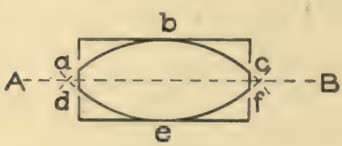


Fig. 170.

Fig. 171.

inside diameter of the rim), and divide the imaginary circle thus formed into five equal parts with the dividers. Draw radii from the points thus obtained, to the center. These radii will be the central lines of the arms, as shown by the dotted lines in Fig. 169.

On each side of the intersection of the radii and outer circle, measure $\frac{1}{2}$ inch to the right and left, and on the circle denoting the circumference of the web, mark $\frac{11}{16}$ on each side of the radii; connect the points thus obtained, and the result will be five arms $1\frac{3}{8}$ inches wide at the web and 1 inch wide at the rim, as shown in the drawing. The ends of the arms which enter the rim should be, in this case, $1\frac{3}{4}$ inches wide, and the sides are drawn parallel to the radius which marks the center of each arm. The curves which connect the arms at the hub must be drawn of such radius as to make the curve tangent to the circle forming the extremity of the web, and also tangent to the sides of the two connected arms as shown at *d*. The small circles at the intersections of the arms with the rim, must be tangent to the edge of the arm and to the circle ($8\frac{3}{4}$ inches diameter) which marks $\frac{1}{16}$ inch less than the inside diameter of the rim as shown at *c c*.

Having laid out the arms as above, and as shown in the drawing by the dotted lines, saw them to shape and round them up to an elliptical form as shown in the cross-section at *e*, Fig. 169. The finished shape of the arm at any point in its length, is found by drawing a cross-section of the arm at that point, as in Fig. 170.

Divide the cross-section equally by the line A B; measure $\frac{1}{16}$ inch; as at *a c d f*; and with dividers adjusted so as to be tangent to the sides of the cross-section of the arm, and to pass through *a c* and *d f*, draw the curves *a b c* and *d e f*.

After filing and working off the sides of the arms to these curves, the angles at *a c d* and *f* are carefully rounded with sand paper, care being taken not to lessen the width of the arm at any point. The result will be as shown in Fig. 171, which gives a strong, firm edge to the arm, and one which will not break or splinter off while being rammed up in the sand.

The arms thus shaped and finished are cut or *let* $\frac{1}{4}$ inch into each half of the rim, and great care must be taken to keep them central with the rim. Before marking the rim for the mortises which will receive the ends of the arms, test their positions with the dividers, spacing from the center of the arms to the outside edge of the rim, and moving the arms until a central position is obtained; after which, with the point of a knife or awl, scribe around the end of each arm, and proceed to cut, with a chisel, the mortises $\frac{1}{4}$ inch deep into each of the half rims, and so cut and fit that the two pieces of the rim may meet and form a close joint, after which they are glued and clamped together over the arms with hand screws.

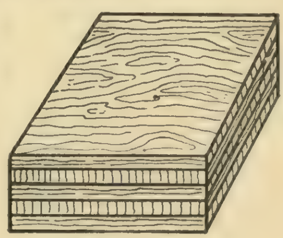


Fig. 172.

The hubs are next turned, each from a solid block, or better from thin pieces $\frac{1}{4}$ inch to $\frac{3}{8}$ inch in thickness, each thin piece being placed crosswise on the other, as shown in Fig. 172. The hubs must be turned with a draft or taper of $\frac{3}{8}$ inch to 12 inches, and have a curve of $\frac{1}{4}$-inch radius at the base where they unite with the arms. After gluing on the hubs, smooth off all connected parts of rim, arms, and hub, and finish with three coats of shellac, sandpapering smooth between each coat, as already described for other patterns.

The making of patterns for special pulleys enters largely into the work of many pattern shops. In these patterns the rims are built up of segments $\frac{3}{8}$ inch to $\frac{1}{2}$ inch in thickness.

To illustrate this work fully, let us take up the successive steps in the construction of a countershaft pulley 20 inches in diameter and of 6-inch face, made to fit a shaft $1\frac{3}{4}$ inches in diameter. The pattern for such a pulley is shown in Fig. 173. The diameter of the web of the arms is 5 inches, and the diameter of the hub $3\frac{1}{2}$ inches at each end and tapering to $3\frac{3}{4}$ inches in diameter at the arms.

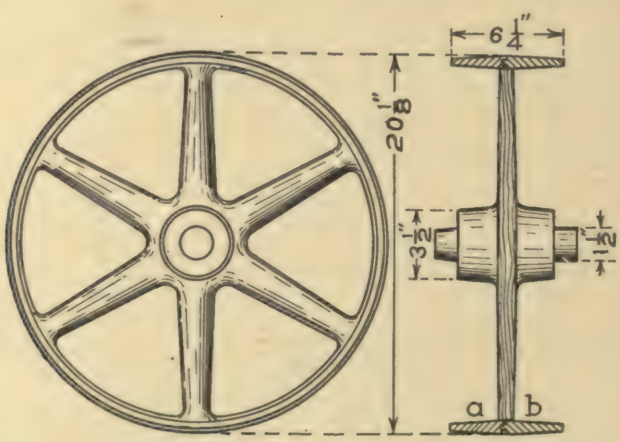


Fig. 173.

If the rim is to be finished on the face and edges only, $\frac{1}{16}$ inch must be allowed for turning, making the outside diameter of the pattern $20\frac{1}{8}$ inches, and the width of the face should be $6\frac{1}{4}$ inches.

In addition to $\frac{1}{16}$ inch for finish, the draft on the outside of the rim, from each edge to the center, should be in the ratio of $\frac{1}{8}$ inch to 12 inches, and on the inside of the rim the draft must be $\frac{3}{8}$ inch to 12 inches.

The thickness of the rim at its edges will be $\frac{5}{16}$ inch, and with outside and inside draft added, its thickness at the arms will be about $\frac{7}{16}$ inch. The inside diameter of the rim at the arms will be nearly $19\frac{3}{32}$ inches. This pulley should have six straight arms

$\frac{3}{4}$ inch in thickness at the hub and $\frac{5}{8}$ inch in thickness at the rim. The width of the arms at the web should be $1\frac{3}{4}$ inches and at the rim $1\frac{1}{2}$ inches exclusive of the connecting curves at web and rim. Six pieces $10\frac{1}{2}$ inches long, $2\frac{3}{4}$ inches wide, and $\frac{3}{4}$ inch in thickness, must be carefully fitted as shown in Fig. 174.

After fitting, the connecting joints are glue sized, and when dry carefully scraped smooth with a sharp chisel, and a saw kerf $\frac{5}{16}$ inch deep cut in each. The tongues used for tenons in these kerfs should be a little less than $\frac{5}{8}$ inch long, the grain of the wood running always at right angles to the line of the joint to give the greatest strength to the tenons.

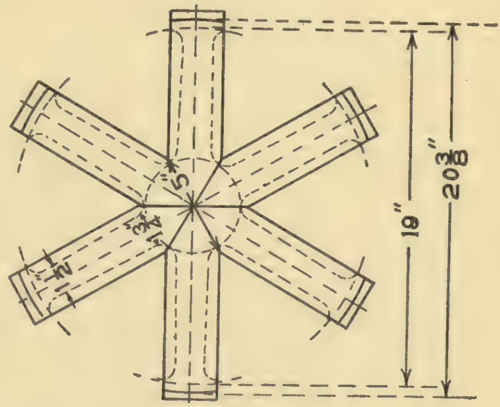


Fig. 174.

The six pieces should be glued in two groups of three pieces each; and when dry, these two groups can easily be refitted, if necessary, and glued.

The next step is to draw, from the center formed by the intersection of the six pieces, a circle 5 inches in diameter, representing the web of the arms, and, near the extremities of the pieces, the arcs of a circle $20\frac{3}{8}$ inches in diameter, representing $\frac{1}{4}$ inch greater diameter than the outside diameter of the rim. Carefully divide these last arcs into six equal spaces with the dividers, bringing the points thus obtained as nearly to the middle of the six arms as possible; and from the six points thus spaced, draw radial lines connecting them with the center or intersection of the six arms. These radial lines (shown dotted in the drawing) will be the center line of each arm.

Saw off the ends of the arms on the above $20\frac{3}{8}$-inch arcs, and from the center again draw on the six arm-pieces a third circle, whose diameter should be at least $\frac{1}{8}$ inch less than the inside diameter of the rim, in this case 19 inches. On these arcs measure $\frac{3}{4}$ inch on each side of the center line, and on the circle representing the web, measure $\frac{7}{8}$ inch on each side; connect these points from web to rim, and the arms will be $1\frac{3}{4}$ inches wide at web, and $1\frac{1}{2}$ inches at the rim.

These lines are shown by the dotted lines in Fig. 174. The width of the ends of the arms passing through the rim should be about $2\frac{1}{2}$ inches, and the sides drawn parallel with the center line of the arm, as shown for hand-wheel arms in Fig. 169. The radius of the circle connecting the sides of the arms and the web, must be such as to be tangent to the edges of the two connected arms, and also tangent to the circle marking the diameter of the web.

The smaller curve connecting the two edges of each arm with the rim must be of such radius as to be tangent to the arm and to the 19-inch arcs which mark the inside of the rim (less $\frac{1}{8}$ inch). All these lines are shown dotted in Fig. 174. The arms are now ready for sawing to shape on the band or scroll saw, care being taken to saw just *outside* of the lines so that each arm may retain its full size and width.

After sawing to shape, the edges must be dressed smooth and free from all irregularities of the sawing.

Next, from the web circle, taper the arms to $\frac{5}{8}$ inch in thickness at the extreme ends, care being taken to see that the taper of both sides of the arms is uniform from the web circle to the rim.

The shape of the arms should be elliptical or nearly so, and a cross-section at any point in an arm may be obtained in the same manner as described for the hand wheel shown in Figs. 170 and 171, and the methods used for shaping and finishing are the same. For building the rim, a wooden chuck $20\frac{1}{2}$ inches in diameter will be necessary.

A board $\frac{7}{8}$ inch in thickness and having a bar 8 inches wide and of the same thickness, well screwed to the back with wood screws will be all that is necessary for a pulley of this size. To the 8-inch bar, the iron face-plate of the lathe is screwed, and the whole turned off true in the lathe, especially the face of the chuck to which the first layer of segments is to be glued.

Strips of heavy paper are often glued between the first layer of segments and the face of the chuck, so that the rim and the chuck may be easily separated when the rim is turned and finished. The paper usually splits, allowing separation without injury to the wood. A better method, however, is to glue twelve blocks, each 2 inches long, 2 inches wide, and $\frac{3}{4}$ inch in thickness, to the face of the chuck, in the same way as that described for the small hand wheel shown in Fig. 168.

When the rim is finished it may be sawed or cut off through the blocks without injury to the chuck and its future use. The segments to form the rim should be six in number for each layer. They should be $\frac{7}{8}$ inch wide, and cut from $\frac{3}{8}$-inch or $\frac{1}{2}$-inch stock, lengthwise with the grain of the board, so as to avoid end wood. The first layer is fitted and glued to the blocks (or to the face of the chuck with paper between), and securely clamped with small hand-screws, three to each segment. When the glue is dry, one hour being sufficient for thin $\frac{3}{8}$-inch segments, place the chuck in the lathe, and carefully turn off the face of the segments true and straight to receive the second layer.

This layer, in turn, is turned off in the lathe and the third layer is glued on, hand screws being used on each layer as on the first, and the joints of the segments so broken that no two will be directly opposite each other, all joints being carried to right or left of all preceding joints, thus securing the greatest possible strength to the rim.

No nails should be used in any work of this description. Having glued on a sufficient number of layers to form half of the rim, turn it to the required external and internal diameters, making the thin or outer edge of the half rim next to the chuck, and carefully giving the required draft to each side.

Before removing the half rim from the chuck, turn a groove $\frac{1}{16}$ inch to $\frac{1}{8}$ inch in depth and of about one third of the width of its thickness in the edge of the rim, as shown in Fig. 173 at *a*. Remove the half rim from the chuck (or cut from the blocks), and proceed to build up and to turn the second half *b* in the same way as the first. Instead, however, of turning a groove on its edge, carefully turn and fit a small projection, or tongue, to the groove in the half *a*, as shown in the drawing. If the work has been done with care and accuracy the groove and tongue will bring the two halves into perfect alignment.

The arms are next fitted centrally to each half of the rim, and the two halves glued together over the arms in the same way as described for the hand-wheel pattern. The projecting ends of the arms are cut off and shaped to form a part of the outside of the rim. The internal curves of the arms at the inside of the rim are also filed and shaped down so as to form true curves without cusps or irregularities. The hub is next glued up in cross-layers as described in Fig. 172, turned out, and glued centrally on each side of the arms.

The pulley being intended for a $1\frac{3}{4}$-inch shaft, the core prints x and y, Fig. 173, should be $1\frac{1}{2}$ inches in diameter, which will give $\frac{1}{8}$ inch of metal for boring out to fit the shaft. The two core prints (Fig. 175) should be turned separate from the hubs, and loosely attached with a pin $\frac{3}{4}$ inch in diameter, and $\frac{3}{4}$ inch long, into each half hub, so that other sizes may be used for larger or smaller shafts. The two half hubs are often made loose so that they may be changed for larger or smaller hubs as may be required for different sizes of shafts. In such cases they are attached centrally to the arms as described for the core prints.

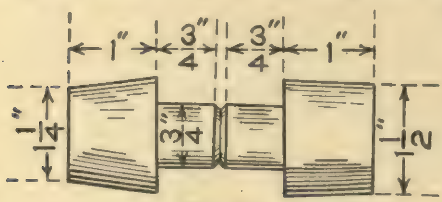
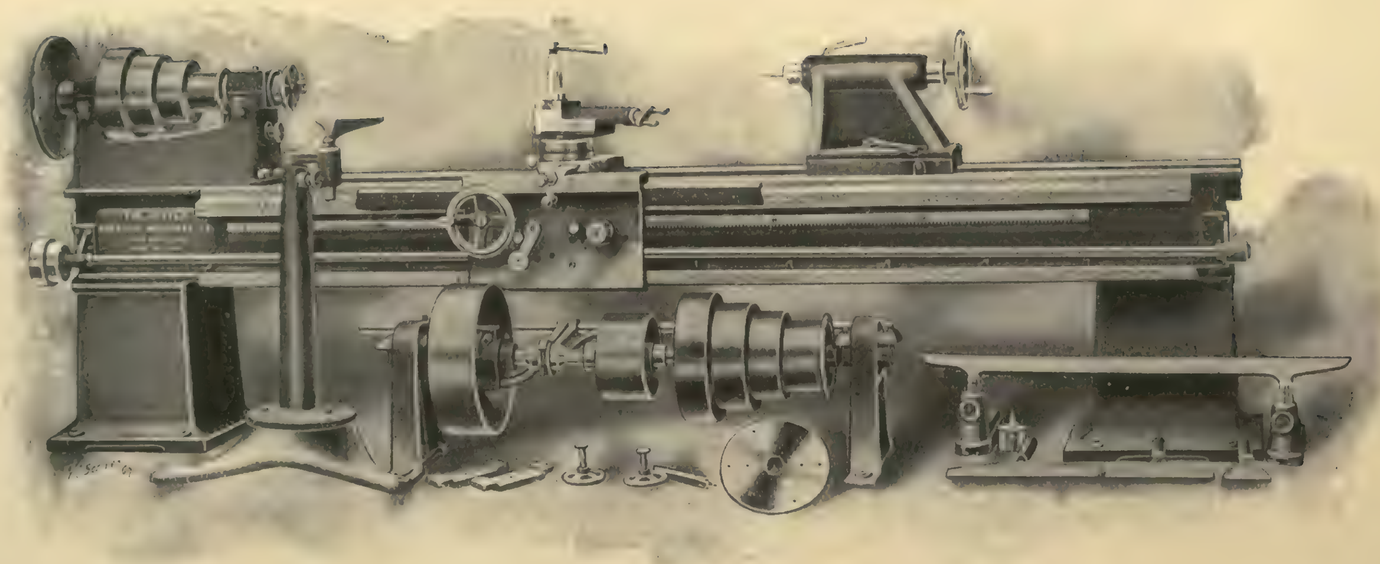


Fig. 175.

A second method in the construction of such special pulleys is as follows:

The half rim having been glued up as described, the *inside only* of this half is turned to the required dimensions and draft, sand-papered, and finished, the width of the half rim being made in this case $\frac{5}{16}$ inch less than the half of the face of the completed pattern. The arms are carefully centered and glued to this half rim; and the intervening spaces between the ends of the arms are filled in with six segments $\frac{11}{16}$ inch in thickness, which, when glued and dry, are planed, *not turned*, true and even with the surface of the arms.

A layer of segments of the regular thickness is fitted and glued on over the arms, and layer after layer continued until the full width of the face of the pattern is reached, thus building the arms directly into their place in the pattern as the rim is glued up. In turning and finishing, care must be taken not to strike the arms with the tools while turning out the inside of the outer half of the rim.



WOOD LATHE.
Oliver Machinery Company.

This method will be found convenient for all pulleys of moderate width of face; but as the spaces between the arms cannot be turned out, great inconveniences in reaching these places will be found when the face of the pulley is twelve or more inches in width. These spaces must be dressed out by hand.

The instructions regarding the construction of the last three patterns should be studied carefully, because the general points involved enter largely into the construction of patterns of all kinds, and especially for all work having arms with circular rims.

When pulleys of standard sizes for line shafting are manufactured in quantities, a skeleton pattern consisting of hub, arms, and an independent iron rim is used. This iron rim is of moderate width but may be used for obtaining any width of face desired.

Wooden patterns complete in themselves, as that described for Fig. 173, are used for all special pulleys on machines when the required sizes and widths, as also hubs and connections, are irregular and designed only for the special machine, so that the making of pulley patterns is important in nearly all foundries and pattern shops.

Where the iron rim is to be made, the same care is necessary in the building up of the original wooden pattern. It must be remembered that before the final casting is obtained, two shrinkages will take place; first, the shrinkage of the original casting from which the iron ring is turned, and then the shrinkage of the casting made from this pattern. In addition to this, there must be the allowance for turning the ring both inside and out and for the turning of the outside pulley rim. Suppose the pattern is to be made for a pulley two feet in diameter. The usual allowance for a single shrinkage is made by the shrinkage rule. In this case the allowance must be doubled. Thus in the above pulley, the diameter of the wooden pattern becomes $24\frac{1}{4} + \frac{1}{4} = 24\frac{1}{2}$ inches, standard rule measurements, or $24 + \frac{1}{4} = 24\frac{1}{4}$ inches, shrinkage-rule measurements. As a very smooth surface, free from holes, is required, $\frac{1}{4}$ inch in diameter, or $\frac{1}{8}$ inch all around, must be allowed for outside finish on the iron ring, and $\frac{1}{8}$ inch for finish on the rim of the cast-iron pulley.

The outside diameter of the original wooden pattern is $24\frac{1}{4} + \frac{1}{4} + \frac{1}{8} = 24\frac{5}{8}$ inches, with shrinkage rule. If the final thickness of the pulley rim is to be $\frac{3}{8}$ inch, this, with the allowance of $\frac{1}{8}$ inch for turning out the inside of the iron ring, makes the inside diameter of the wooden pattern 23 inches, and the thickness of the wooden rim $\frac{13}{16}$ inch, all shrinkage-rule measurements.

This wooden-ring pattern must be built up on a chuck, as described for the 20-inch × 6-inch pulley, the segments, six in number for each layer, fitted, glued, and clamped with three hand screws to each segment until a width of 6½ inches is reached.

It is then turned to the above dimensions, *without any draft*, and sent to the foundry, where it may be used for obtaining an iron rim of any required width by first ramming the sand about the pattern, partly drawing it, and then ramming again to a new level.

The casting thus obtained is then turned to the dimensions called for by an ordinary pattern; that is to say, the shrinkage-rule measurements would leave it 23¼ inches in diameter on the inside and 24⅛ inches on the outside, permitting a final finishing of the outside of the rim of the pulley to a diameter of 24 inches. When this is done, two $\frac{3}{8}$-inch holes should be drilled near one edge of the rim and diametrically opposite each other, into which hooks may be inserted for drawing the pattern. This rim should also be turned straight and without any draft.

The arms are usually made with a wooden pattern, which has a dowel-pin hole on each side at the center for attaching the hubs that are loose, the object being to change their length and diameter to suit the width of the rim and the diameter of the shaft upon which the pulley is likely to be placed.

The arms of all pulleys should be straight because of the greater strength given to the pulley as a whole, the driving and resisting power being at least one-third greater than in a pulley of the same dimensions having curved arms. Curved and shaped arms of all kinds are now used only for ornamental purposes and for very light work.

The arms should be six in number, except for very small pulleys, when five and even four are often used. The dimensions of the arms vary greatly, depending on the purpose for which the pulley is to be used, and the weight of the machinery to be driven.

For the beginner the following formula is safe to follow:

$$b = \sqrt[3]{\frac{d \times w}{n \times 8}}, \qquad \text{in which}$$

b = the breadth of the arm at the outer end,
d = the outside diameter of the pulley,
w = the width of the rim,
n = the number of arms,

all dimensions being taken in inches. Thus, for a pulley 24 inches in diameter with a rim 6 inches wide and fitted with 5 arms, the formula becomes·

$$b = \sqrt[3]{\frac{24 \times 6}{5 \times 8}} = \sqrt[3]{3.6}$$

Hence, $b = 1.53$ inches or $1\frac{1}{2}$ inches.

The width of the arm should be one-fourth greater at the hub than at the rim. The thickness at the hub and rim should be one-half the width, and the section should be elliptical. The arm just calculated then becomes,

1½ inches wide at rim,
¾ inch thick at rim,
1⅞ inches wide at hub,
1 inch thick at hub.

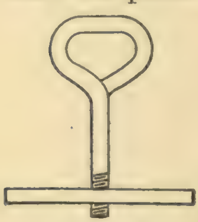
For the skeleton pattern last described, the common method of constructing the pattern for the arms, is to make each arm of a separate piece of wood with the grain running in the general direction of the arm, and to fasten them together at the center with glue and a flat plate or disc, which can also be used as a rapping plate. This pattern need be parted only in the case of very large and heavy wheels. For all ordinary work it can be made in one piece and moulded as directed in connection with the hand wheel, Fig. 167.

HUBS.

An ordinary rule is to make the outside diameter of the hub twice the diameter of the shaft. The two half hubs (one on each side of the arms) are usually loose and are held central by a single dowel pin. Their diameters are adapted to the size of the shaft upon which the pulley is to run, and the length is proportioned to the width of the rim as well as its diameter. The length of the hub should be about two-thirds the width of the rim except in the cases of tight and loose pulleys, where the hub should be a trifle longer than the width of the rim. It may then project about $\frac{1}{8}$ inch on the sides in contact, and $\frac{1}{4}$ inch on the outside.

RAPPING PLATES.

In the description of the making of the pulley pattern, the ring serving as a binder for the hub is spoken of as a rapping plate. When a pattern is imbedded in the sand, the latter is closely compressed all about it, and slightly adheres. The moulder is, therefore, in the habit of rapping the pattern gently in order to loosen it in the sand before attempting to draw it. If the pattern is not provided with a metal plate, the moulder will drive the sharp point of a lifter into the wood and strike it alternately on opposite sides and at the same time use it to lift the pattern from the sand. This mars the pattern and will in time ruin it. The rapping plate, shown in the engraving, is a piece of thin metal $\frac{1}{8}$ to $\frac{3}{16}$ inch thick, inserted so that it is flush with the parting face of the pattern and is held by wood screws with countersunk heads. These plates are drilled and tapped for a $\frac{3}{8}$-inch screw and should be the same for all patterns in the foundry so that one set of rods can be used interchangeably. The method of using is to screw the rod into the plate and rap it gently to and fro until the pattern has been loosened, when it may be lifted. For small patterns, one rapping plate will be sufficient and this should be so placed that the hole for the lifting rod comes directly over the center of gravity of the piece. This will prevent tilting of the pattern as it is lifted from the sand. For medium sized patterns, two rapping plates should be provided, so that the pattern can be raised from two opposite sides. For still larger patterns three or four rapping plates are used; the object being to give such perfect control when drawing that there can be no tearing away of the sand.



Rapping Plate.

METAL PATTERNS.

Metal patterns are extensively used where either one of two conditions prevail: first, where the character of the work is so light and delicate that a wooden pattern could not hold together, as in ornamental castings; and second, where such a large number of castings are to be made that the wooden pattern would not last long enough to complete the work. Metal patterns may be made of iron, brass, or aluminum. The latter metal is coming into great favor because of its light weight and its freedom from corrosion by the moist sand. These patterns should be given a light coating of shellac varnish, but it is not absolutely necessary. Where iron is used, some preservative must be put upon the surfaces to protect them from rust. The best method is to warm the metal and rub it with a rag dipped in melted beeswax. This excludes the air and leaves a smooth surface so that it is easily drawn out of the sand. This, however, is not a very durable protection; the more common method is to use a shellac varnish. In order that the varnish may adhere, the metal should first be wet with a solution of sal ammoniac, and, when dry, sand-papered and shellaced.

In the small 12-inch crank pattern shown in Fig. 176, is shown a very simple *one-piece* pattern. In spite of its simplicity it requires considerable skill in shaping and in obtaining the necessary draft. The parting of the mould will be on the line C D. The piece *e*, for the main body of the pattern, should be made rectangular in form, and laid off with center lines from which the positions of the bosses *c*, *b*, and *d*, and the core print *x* may be drawn on the upper and lower sides respectively. The bosses are turned on the lathe to the required form, and given a draft of ¼ inch to 12 inches. After *b* and *c* have been glued on, the part *e* is sawed to shape, sawing close to, but not touching *b* and *c* with the saw. The thin boss *d* is next glued in place, after which *e* is filed and dressed to the required shape and even with *b* and *c*, giving it the same draft, ¼ inch to 12 inches, but in the opposite direction from the parting line C D. The rib *a* is next turned on the lathe, and one side split off on the band saw, after which it is fitted between *b* and *c*. The core prints may be turned with a small tenon on one end to fit into

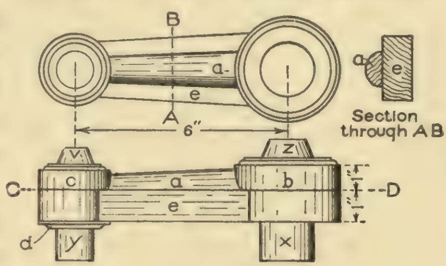


Fig. 176.

holes bored in the pattern, or they may be turned flat on both ends and nailed on. Core prints *x* and *x* must have no more draft than is given to the body of the pattern ($\frac{1}{4}$ inch to 12 inches); but *z* and *z*, which will be moulded in the cope, must be $\frac{1}{4}$ inch less in diameter at the upper end than the diameter at the base.

The heavy engine-crank pattern illustrated by Fig. 177, differs but little in general construction from that shown in Fig. 176, except that, being large and heavy, it must be built up out of thin stock, as shown in the drawing.

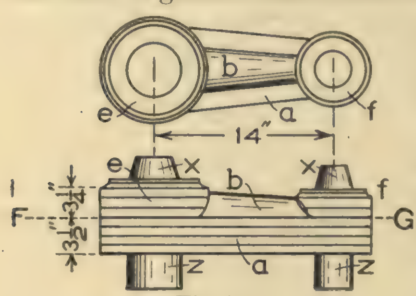


Fig. 177.

The stock is first glued up to the necessary thickness, after which it is laid out and sawed to shape as one piece, the saw table being tilted slightly to give the required draft, which in this case must not be more than $\frac{1}{8}$ inch or $\frac{3}{16}$ inch to 12 inches.

The bosses *e* and *f* are also glued up out of thin stock, the pieces being crossed so that the grain of each will be at right angles to that of the other, as illustrated in Fig. 172, after which they are turned with a draft of $\frac{1}{4}$ inch to 12 inches, and fitted to *a*.

Of the four core prints only *x* and *x* will have excessive draft, as explained in connection with Fig. 176; *z* and *z* must have no more draft than the body of the pattern: The parting of the mould, as in the former case, will be on the line F G.

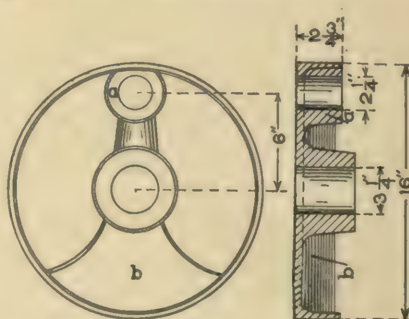


Fig. 178.

In Fig. 178, is illustrated a finished cast-iron *disc crank* for an engine of 12-inch stroke. This crank is finished on the face, on the outer edge, and on the end of the hub. It is bored out $3\frac{1}{4}$ inches to fit on the engine shaft, and $2\frac{1}{4}$ inches to receive the wrist pin. An addition of $\frac{1}{8}$ inch must be allowed on the pattern for finish of the face, and the same on the end of the hub; $\frac{3}{16}$ inch will be sufficient to add for finish on the outer rim, making the diameter of the pattern $16\frac{3}{16}$ inches, and the thickness of the disc $\frac{9}{16}$ inch. A sectional view of the pattern is shown in Fig. 179.

The disc for this pattern must be made of two thicknesses of sectors, six in number for each thickness, which, after being fitted, glue-sized, and glued together, are planed off true on both sides, and glued on each other so as to break joints, as shown in Fig. 180. When dry, the disc thus obtained is sawed to a diameter of $16\frac{1}{2}$ inches and glued to the wooden chuck on the iron face-plate of the lathe with small sectors of thick paper between, or else glued to small blocks on the chuck, from which, after turning, it can be cut as illustrated in Fig. 168. The rim is now built up on the disc out of segments $\frac{3}{8}$ inch or $\frac{1}{2}$ inch in thickness, as directed for the 20-inch pulley (Fig. 173), with not less than six segments to each course. The hub is glued up as described, and, after gluing on the disc, the whole is turned to the required size and shape.

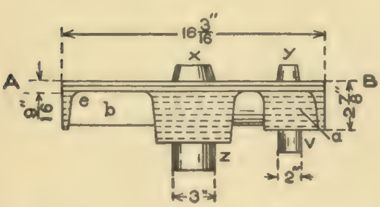


Fig. 179.

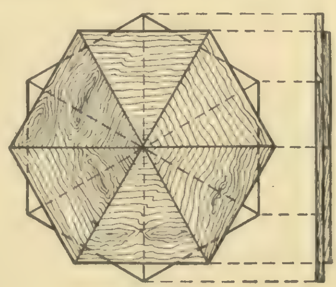


Fig. 180.

In the case of this disc-crank pattern, a small disc of paper (or a block, if blocks are used) should be placed, without gluing, under the center of the disc, to prevent looseness and vibration while being turned in the lathe. The boss *a*, to receive the wrist pin, must be glued up in the same way as the hub (see Fig. 172), and turned on the lathe, after which it is fitted into position as indicated in Figs. 178 and 179. The counter-weight *b* is next shaped from a single piece, or it may be glued up of several thicknesses of $\frac{1}{2}$-inch stock. In sawing this block to shape, the band-saw table should be tilted so as to give it a draft of $\frac{3}{8}$ inch to 12 inches. Give the inside of the rim, the hub, and the boss *a*, the same draft, but the outside of the rim should not have a draft of more than $\frac{1}{8}$ inch to 12 inches.

When turning on the inside of the rim, a *fillet* or curve must be made where it joins the disc, of ⅜-inch radius, as shown at *e*, Fig. 179. The same curve must be turned at the base of the hub. Around the counter-weight block, and also around the wrist boss, a ⅜-inch leather fillet can be used.

For convenience in moulding, the two core prints *x* and *y* should be turned with a tenon ¾ inch in diameter and ¾ inch long, to fit into the holes in the face of the disc, so that they can be removed when the pattern is laid on its face on the moulding board. The core prints *v* and *z* are turned without tenons, being glued and nailed in position.

FILLETS.

The fillets spoken of in connection with Fig. 179, are used in all except the most simple patterns. They consist of a small quarter curve varying in size from ⅛ inch radius upward, depending on the size of the pattern and the room they can be allowed to occupy. They should be placed in all corners, wherever possible, so that there may be no sudden changes in the direction of the surface of the casting, which causes weakness, the fillets adding greatly to the strength of the casting.

Fig. 181.

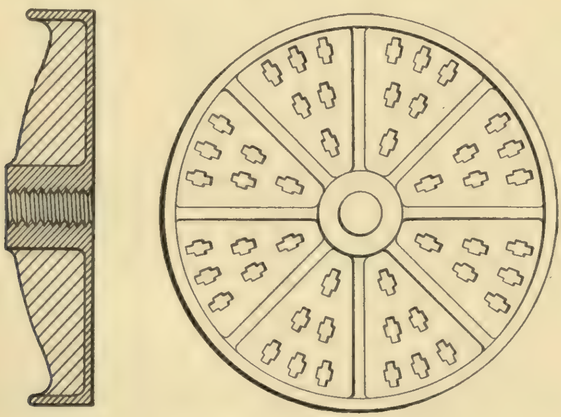
These fillets are made in various ways, the wooden fillet, cut as in Fig. 181, being commonly used for all long, straight angles, or for very flat curves to which it can be bent.

For irregular angles and for short radius curves, beeswax was formerly used, but the modern *leather fillet* has almost entirely superseded beeswax and other material for this purpose. It is easily applied, shaping and adapting itself to any and all positions and angles. It can be bought in all sizes from ⅛ inch up, the sizes running by sixteenths. The method of applying it is to cut it to the necessary length and lay it on a board where the glue can be easily brushed over it. It is then laid in the angle and rubbed into position by means of a dowel rod, the end of which must be rounded off as shown for the connecting dowel pins of a parted pattern, Fig. 152. The dowel rod must be of such size as to impart the required curve to the soft, pliable leather fillet. As soon as the fillet is rubbed into position all surplus glue must immediately be wiped off before it sets. This is easily done with a small piece of waste or a rag dipped in the hot water of the outer glue-pot and wrung out nearly dry, care being taken not to wet any part of the pattern more than can possibly be helped, after which it must at once be wiped dry.

These leather fillets will be found more pliable and more easily placed and rubbed into position if the glue used is first allowed to cool slightly. Very hot glue stiffens and crinkles the leather, causing it to work hard.

FACE PLATE.

It is sometimes advisable to use cores even if it is quite possible to construct the pattern so that it would core its own holes. This is the case where it is desired that the faces of the casting and the holes shall be smooth and as true as possible without expensive



a. Fig. 182. *b.*

machine work. The finished face-plate of an engine lathe illustrated in Fig. 182 is a good example of such work.

It will be readily seen that the pattern for this casting could be put in the sand and withdrawn from the mould, leaving the sand standing where the holes are located.

The trouble that arises from this method is due to the fact that when the metal is poured and allowed to flow about the fragile projections that are left to form the holes, the sand washes away, so that the holes in the casting are irregular and much smaller than those in the pattern. For these reasons the holes should be cored, as the core sand is firm and better able to resist the washing action of the flowing metal.

The patterns for such a face plate, a cross-section of which is shown in Fig. 183, should be made as follows: The allowance for finish on the face of the casting should be not less than $\frac{3}{16}$ inch, and the same should be added to the diameter and also to the end of the hub. Having thus determined the thickness and size of the pattern, the disc should be built up of from four to sixteen sectors, according to the size of the plate. If the diameter is between 24 and 42 inches, sixteen sectors should be cut out, each filling an arc of 45°, so that when eight are placed edge to edge they will complete the circle. The thickness should be a little more than one-half the completed thickness of the pattern disc, and they should be laid up so as to form two layers, breaking joints with each other as shown in Fig. 180. When the disc is formed, the hub should be first glued in position, this also being built up of pieces glued together, and the whole attached to a large wooden chuck and iron face-plate of the pattern lathe in the same manner as described for the disc-crank (Fig. 178). The rim is next built upon the disc in the same way as has been described for former patterns. If the face plate is very large, the segments may be $\frac{1}{2}$ inch or even $\frac{5}{8}$ inch in thickness, and to avoid end wood, eight, twelve, or even sixteen, segments may be used for each layer according to the diameter of the rim.

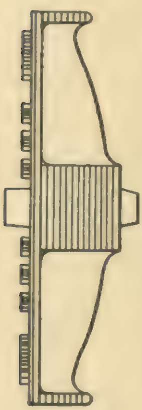


Fig. 183.

The pattern now consists of the disc with the rim and hub in position, but larger than they should be. It is, therefore, placed in the lathe and carefully turned over its whole surface, each part and thickness being brought to the shape and dimensions of the completed pattern, care being taken to turn in a fillet of $\frac{1}{4}$ inch to $\frac{1}{2}$ inch radius, depending on the size of the required casting, in the angles connecting the rim and the hub with the disc. Next put in the ribs; it is not necessary to form these out of built-up material, for each may be cut from a single piece. They should be carefully fitted to form a close joint with the rim, the disc, and the hub, before they are glued in position. When this is done, all angles formed by the rim, ribs and hub with each other should be carefully filleted.

After the fillets are in position, it remains to provide for the coring of the holes. This is done by first laying out upon the face of the pattern the location and size of the holes. It is upon the points thus located that the core prints are placed. Before this is done it must be decided which side of the casting is to be made uppermost.

Where a large, flat surface is to be given a finish, it is desirable that the metal should be as clean and free from sand and blowholes as possible. As the iron has a greater specific gravity than the sand of the mould, all particles of sand that may be washed away and all gases generated, rise to the surface of the molten metal. Those imprisoned by the cooling of the iron form the dirt and blowholes that disfigure the completed casting. In a casting such as the face-plate under consideration, it is desirable, then, that the face should be upon the lower side when the metal is poured. For the sake of convenience in setting the cores, the prints are put upon the face and make their impress in the sand of the drag. They should be glued and nailed in position after the pattern itself has been sand-papered. The core prints for the hole through the center are also put on in the same way.

PIPE CONNECTIONS.

Many patterns which at first may seem to be quite formidable, will, after a little study, resolve themselves into a few very simple parts, nearly all the work for which may be done in the lathe. Of this the tee pipe connection shown in Fig. 184, is a good illustration.

A sectional view of the casting, threaded and having a pipe screwed into the right-hand end, is shown in Fig. 185.

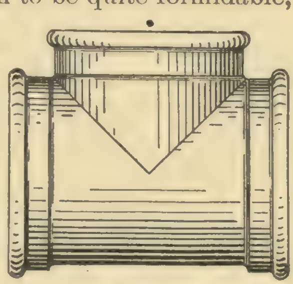


Fig. 184.

The completed pattern for this casting is illustrated in Fig. 186, with its core prints *a*, *a* and *a*, and must be parted as shown in Fig. 187. The entire pattern may be made at a single turning as illustrated in Fig. 188. The preparation of the wood for this pattern is similar to that described for the pattern of the brass bearing, Fig. 150; the two halves having the necessary dowel pins inserted, and glued together at the extreme ends only.

When there is not time for the glue to dry, all such *parted* work may be held together while being turned, by having staples driven into the ends as shown in Fig. 188. Indeed, for all large and heavy work this method is to be preferred; two, and even four, staples being used in each end as the size of the work may demand. When the turning is completed, it is only necessary to cut a V-shaped opening into the two halves of *e*, into which the part *f* is fitted and glued. When the glue has set and is sufficiently dry, the joint may be further strengthened by nailing, or by inserting and screwing a thin metal connecting plate flush with the parting side of each half of the pattern. This, however, will be necessary only when patterns are large and heavy, or when unusual strength is required.

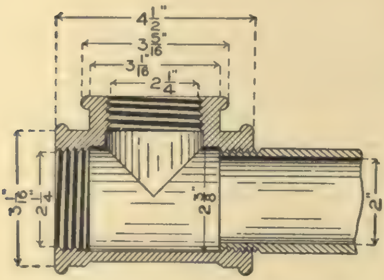


Fig. 185.

The core box for this pattern, as will be seen in Fig. 189, is the usual half box and is made by working out the box in one piece, long enough to make the two parts *a* and *b*. The two parts are united by cutting a V-shaped opening in the part *a* and fitting *b* into it in the same way as described for the pattern. The whole is then glued and screwed to the board *c*, and the two triangular blocks *d* and *d* are glued in the angles to add strength to the completed box. In case the pattern is for a very small pipe, $1\frac{1}{2}$ inches or under, the part *b* may be abutted against the side of *a*, as shown by the dotted line, and the side of *a*

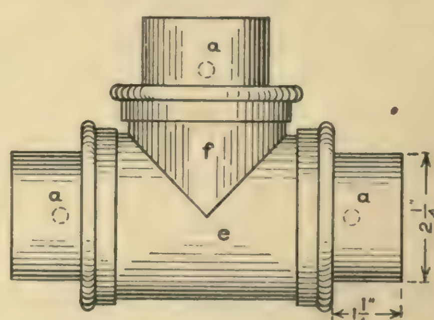


Fig. 186.

at *e* cut away to the same curve as *b*, giving the same results as in the former method.

The pattern for the 2-inch elbow, Fig. 190, is another illustration of how such work may be simplified, and time saved, by doing the greater part of the work in the lathe.

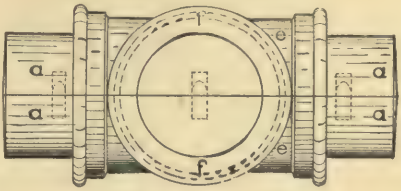


Fig. 187.

As these elbows are usually cast in large numbers, the pattern should be made double as shown in Fig. 191. To construct the double pattern, a ring is first turned like Fig. 192, a cross-section of which is a semicircle as shown in the lower right-hand corner of the drawing. This ring

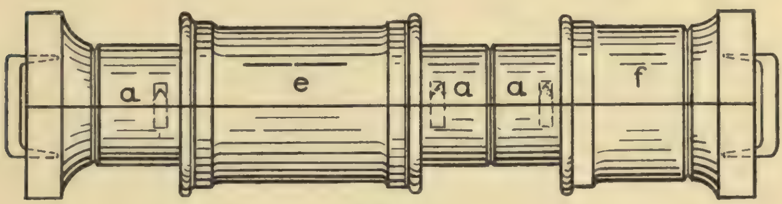


Fig. 188.

is cut into quarters, and the four pieces *e*, *e*, *e* and *e* make the quarter turns for the two halves of the double pattern.

The ends, including the core prints and connecting tenons, are

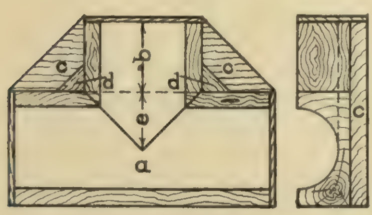


Fig. 189.

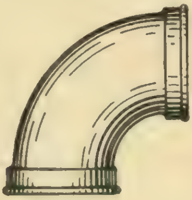


Fig. 190.

turned in one piece as shown in Fig. 193, the stock for which is prepared, with the inserted dowel pins all in position in the same manner as described for the tee pattern, Fig. 188. The quarters, *e*, *e*, *e* and *e* are clamped together two and two, and the ends carefully bored to receive the tenons which are then glued in position and further strengthened by a wood screw as shown in Fig. 191.

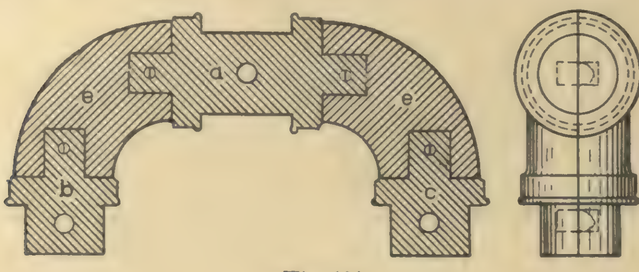


Fig. 191.

In Fig. 194, the core box for this double pattern is shown, and as will be seen the most difficult part of the work can be done in the lathe. Fig. 195 shows two pieces jointed and clamped together which must be screwed to the face-plate of the lathe and turned out to make the two corners *c* and *c*. The three straight parts *d*, *d* and *d* are worked out in one long piece and afterwards cut to the required lengths, after which the five pieces are glued and screwed to the board *a*. The ends *e*, *e* are next put on and the required half core box is complete.

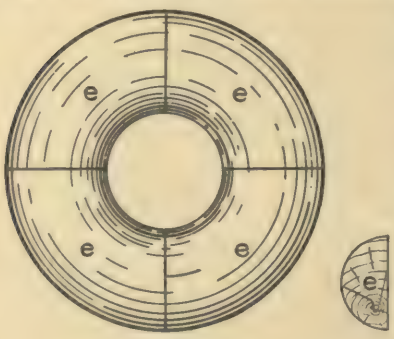


Fig. 192.

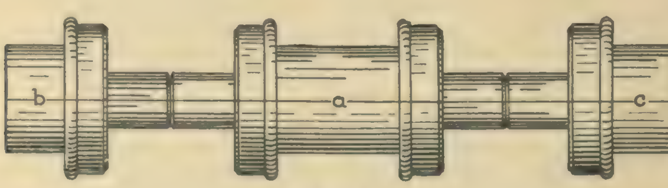


Fig. 193.

Another reason why the pattern for pipe elbows should be made double is that otherwise the core prints would require to be made of great length in order to balance, sustain, and keep the heavy core in position; the tendency being to sag in the middle, or float on the molten iron, and thus make the upper side of the casting too thin, all of which is avoided in the double pattern.

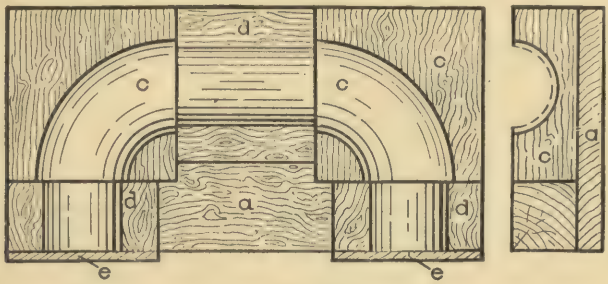


Fig. 194.

A pattern for the return bend, Fig. 196, can be built up and constructed in the same manner as described for the elbow; the semicircular returns, not only for the pattern, but also for the core box, being turned in the lathe, together with the ends and core prints for the pattern. As there will be no middle support for the core in this case, the core prints must be made, as shown in the half pattern, Fig. 197, of sufficient length to balance the heavy semicircular core, and also to keep it in its true position in the mould.

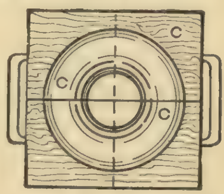


Fig. 195.

The small wood lathe chuck, a vertical section of which is shown in Fig. 198, will serve as a simple illustration of the long

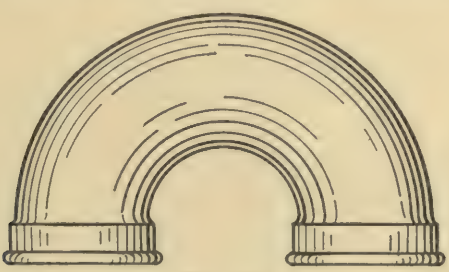


Fig. 196.

core print and *balanced* core. The casting must be counter cored; that is, the cored opening must be enlarged at the forward end, adding to the size and weight of that end of the core, which, as will be seen, has no support except that afforded by the extra length of the core at the opposite end. The pattern for this chuck is shown in Fig. 199, and the core print must have a length at least twice as great as the depth of the hole in the chuck. The core box is shown in Fig. 200.

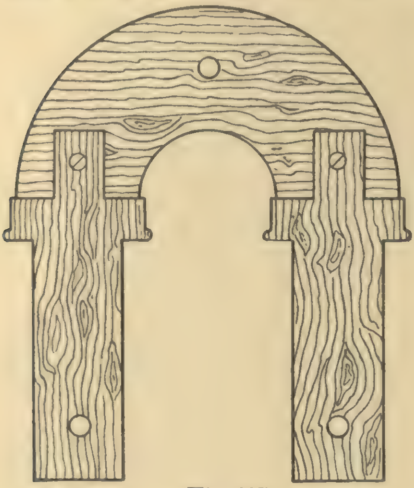


Fig. 197.

When pipes or cylinders are of moderate size with deep flanges for bolting together (Fig. 201), the flanges for the pattern are turned out of a separate disc as shown in Fig. 202, and firmly glued and nailed on over the core prints and against the ends of the main body of the pattern; the core print being made of sufficient length to receive the flange. A recess is sometimes turned in the inside end of the core print to receive the inner edge of the flange as shown in Fig. 203, and into which it is fitted, thus adding greatly to the strength of the joint.

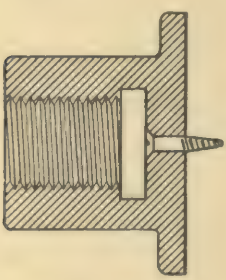


Fig. 198.

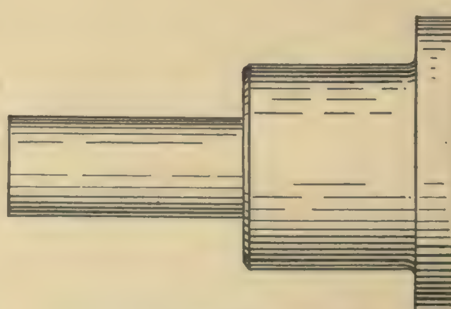


Fig. 199.

The flanges should be made by gluing up *three* pieces and crossing the grain of the pieces so that the grain of each will run at right angles to that of the other. In gluing pieces together for thin discs, *three* pieces should always be used. *Two* thin pieces glued together will always warp.

A still better and stronger method of making large flanges is to cut out segments, five or six for each course, and fit and glue up on a chuck and face-plate in the same way as described for the hand wheel rim (Fig. 168); two or three courses being used for each

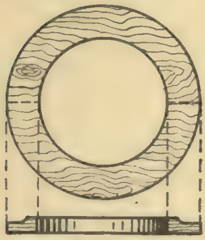


Fig. 202.

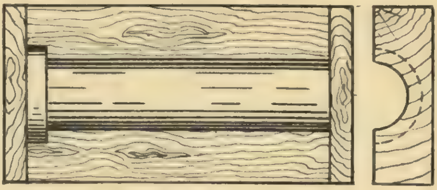


Fig. 200.

flange, which after being turned to the required size and form, the ring is sawed in two with a very thin saw, and each half fitted into place on the pattern. The main body of the pattern is glued up

Fig. 201.

out of strips as shown at *a*, Fig. 204, and for turning, the two halves are held together by means of staples as shown in Fig. 188.

A short temporary block is then fitted and glued into the

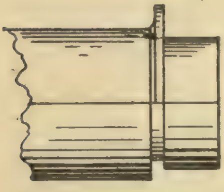


Fig. 103.

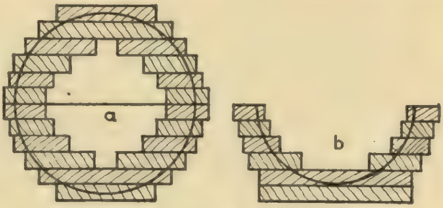


Fig. 204.

opening in each end to receive the lathe centers. A staple plate, similar to that illustrated in Fig. 205, may be used to great advantage for all work of this kind, making as it does, a secure connection and doing away with the otherwise temporary center block.

The method of constructing the core box for this or similar patterns, is shown at *b*, Fig. 204.

Tees, elbows, and other bends and connections, when large, are built up in a similar way, thus making a lighter, and also more durable pattern.

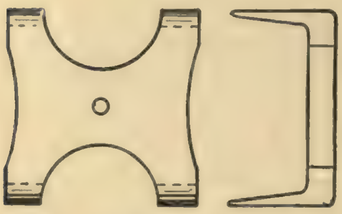


Fig. 205.

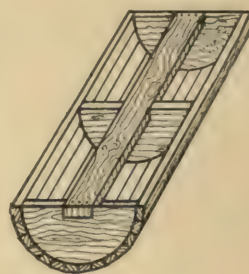


Fig. 206.

For large cylinders, a much lighter and simpler method of constructing the pattern is shown in Fig. 206. For each half of the pattern the two end discs, and the middle semicircular disc are connected together by a strong center bar, which is fitted, glued

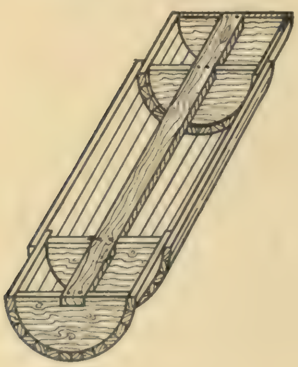


Fig. 207.

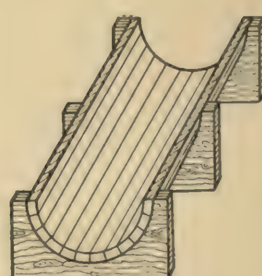


Fig. 208.

and screwed into each, serving not only to strengthen the pattern, but also to hold the connecting dowel pins. When the two halves of the pattern are clamped together (with staples) it serves also as a secure means of centering in the lathe.

The staves forming the body of the cylinder are fitted and glued to each other and screwed, or nailed to the discs. After the cylinder has been turned, the core prints and flanges are built up and turned separately, and glued and screwed to the ends of the cylinder from the inside of the end discs.

Fig. 207 illustrates still another and better method of building up the cylinder and core prints in one piece and completing the whole at a single turning. The core prints, as shown, are staved up first, and then the staves to form the body of the pattern are fitted, glued and screwed, or nailed, over the ends of those which form the core prints. Should the body of the cylinder be long, one, two, or more middle semicircular discs must be used.

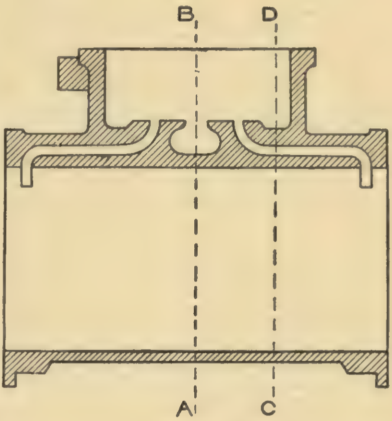


Fig. 209.

A similar construction for the core box is shown in Fig. 208, and is to be preferred to all others because if laid out and built to the exact size, the labor required to reduce the staves to a perfect semicircle of the required radius is very little.

ENGINE CYLINDER.

The slide-valve engine is built in a great variety of forms. Fig. 209 represents a sectional view of the cylinder of a very common type. At *e* Fig. 210, we have a cross-section through the steam chest and exhaust port at *A B;* and at F, a cross section at *C D* through the steam port.

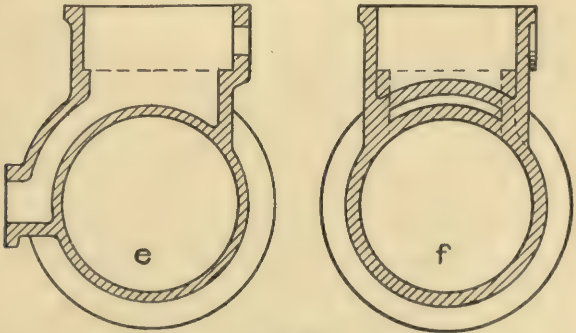


Fig. 210.

When the cylinder is small (ten inches or under in diameter) the pattern is usually built up solid, but if more than ten or twelve inches in diameter it should be built of staves, as shown in Fig. 211.

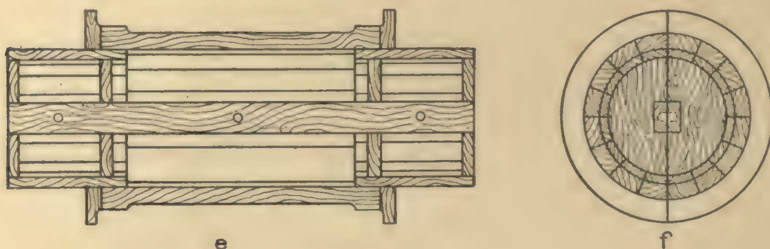


Fig. 211.

When the size is thirty inches or over, a loam mould is usually made as will be fully described in the section on Foundry Work. The size limit, however, varies greatly in different foundries.

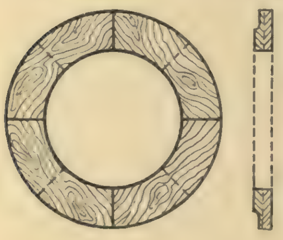


Fig. 212.

The construction of the pattern is illustrated in Fig. 211, and needs no description here, it being the same as already given for Fig. 207. The flanges, however, should be built up of segments of two or three layers each as shown in Fig. 212. After gluing up to the necessary thickness to make the flange, it is sawed in two halves, jointed and carefully centered on a wooden chuck and turned to the dimensions required.

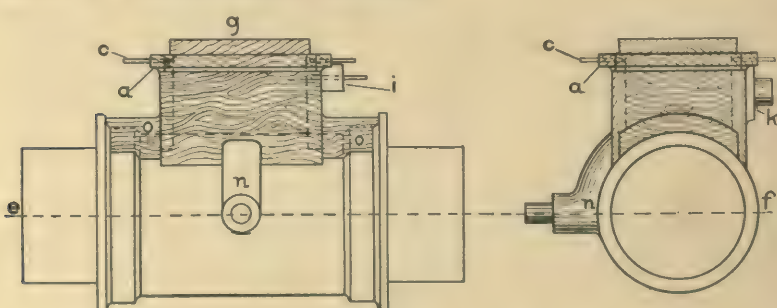


Fig. 213.

The centering must be done with accuracy, or one half of the flange ring will be larger than the other. The steam chest is next built and fitted centrally on the upper half of the cylinder pattern as in Fig. 213. The projections *a*, *a*, which give the extra width of metal for the bolts of the chest cover are left loose, being kept in place by long wires or dowel pins as shown at *c*, *c*, so that they

Fig. 214.

can be withdrawn separately from the mould after the main part of the pattern has been taken from the sand. These four strips should be recessed into the corners of the chest one quarter inch, as shown by the dotted lines, to prevent them from being rammed out of place after the dowel pins are taken out. The boss *i* for the valve-rod stuffing box, and also the boss *k* around the steam-pipe opening, must be loose so as to be taken out of the mould after the pattern has been removed.

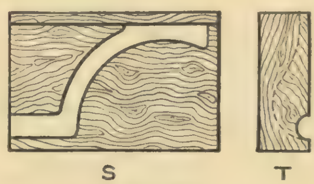


Fig. 215.

The pieces *o*, *o*, at each end of the steam chest, which form a thickness of metal over the steam ports, are next fitted in place, as also the exhaust passage *n* which must be parted on the line of parting of the two halves of the cylinder pattern.

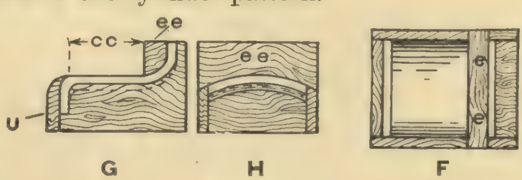


Fig. 216.

The main core box for the cylinder is made in the same way as has been already described for Fig. 208. The steam-chest core box is shown in Fig. 214, in which P is a side view, one side of the box being removed to show the valve seat *v*, and the core prints *x*, *z*, and *y*, which form recesses in the core, into which the upper ends of the two steam inlet cores, and the central exhaust passage core are placed. Q is an end view of the box with one end removed, and R is a view looking into the box from above.

For the core forming the exhaust passage, two half core boxes, one right and one left, will be necessary. One half of this box is illustrated at S, Fig. 215, as also a sectional view at T. The dotted lines show the manner in which the passage is widened to retain the full size of the opening throughout.

Only one core box will be needed for the two steam ports. Three views of the box are given in Fig. 216. At G one side is removed, giving a side view of the construction of the box. H shows a cross section through G with the end *u* removed, and F is a view from above. The core is swept off on the upper side for the length of *c c*, and the bar *e e* as well as the end *u* must be movable so that the core can be taken from the box. Both ends of the core change from circular into straight parts just at the entering of the cylinder, and at the entering of the steam chest.

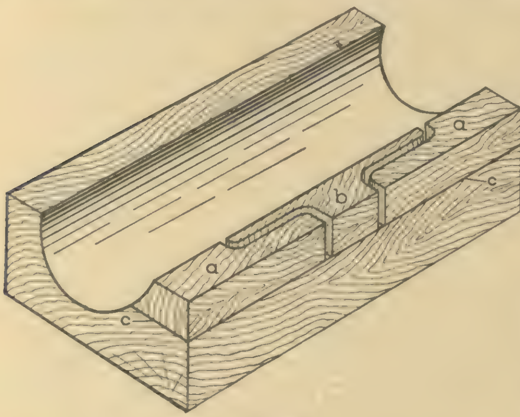


Fig. 217.

The entire set of patterns are simple and easy of construction, if carefully made drawings are furnished to work from; the time and labor required, depending entirely upon the size of the cylinder.

In some slide-valve cylinders, the steam chest is cast separate and bolted to the cylinder, thus affording free access to the valve seat *v*, and a better opportunity for finishing and fitting. In this case the main cylinder core and the two steam inlet cores are made together in the same box, as illustrated in Fig. 217, in which one side of the core box is cut away to a depth of one half of the length of the steam port openings, or to the line *c*, *c*, which must be just one half of the inside width of the box as shown at *H* and at F, Fig. 216.

The part which has been cut away is replaced by the three blocks *a*, *a* and *b*, which are shaped to give the required size and form to the steam-port cores.

These blocks are fastened by dowels, loosely, to the main part of the core box, and after the core has been rammed up, the whole box and core is turned over on its face and the main part of the box is lifted off, after which the two loose blocks *a* and *a* can be drawn away endwise and the block *b* can also be lifted out with ease.

GLOBE VALVE.

The globe valve, shown in section in Fig. 218, is a good illustration of a pattern in which, while the outside may be very simple, the inside is intricate and requires considerable practice

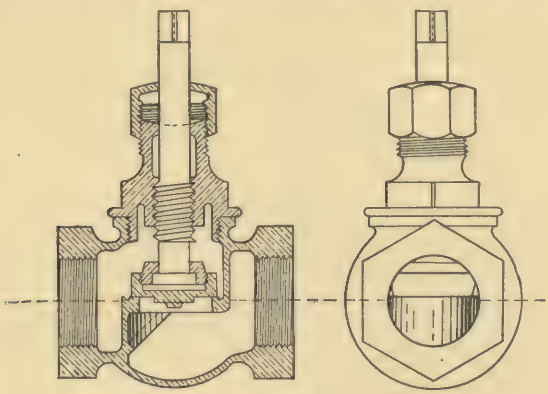


Fig. 218.

and skill to so contruct the core boxes that the core can be withdrawn from them, and at the same time give uniform thickness and strength to all parts of the shell and to the internal partitions.

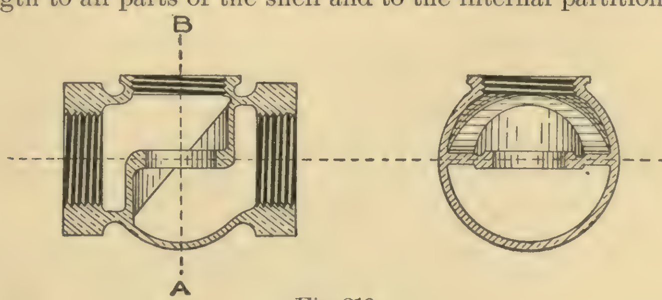


Fig. 219.

In Fig. 219 is shown a sectional view of the body of the valve, and in Fig. 220 an illustration of the completed pattern, from which it will be seen that almost the entire work, with the exception of fitting, placing the dowel pins, and forming the two hexagonal ends, is done in the lathe. The construction is shown in the sectional illustration of the half-pattern, Fig. 221. The wood for the two halves must be of sufficient length to allow for gluing at each end or for the insertion of iron staples. In turning, the greatest care must be taken to center exactly on the parting line of the two halves.

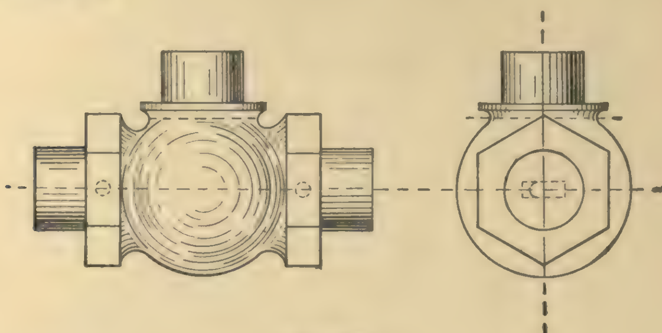


Fig. 220.

A carefully shaped template, such as is shown at *a*, Fig. 221. must be used in turning. This template may be made of a thin piece of wood, but for all purposes for which templates are required in pattern making, and their use is necessarily very great, sheet zinc is the best material. It is soft, and easily cut and filed, and does not dull the cutting tools so much as other metals

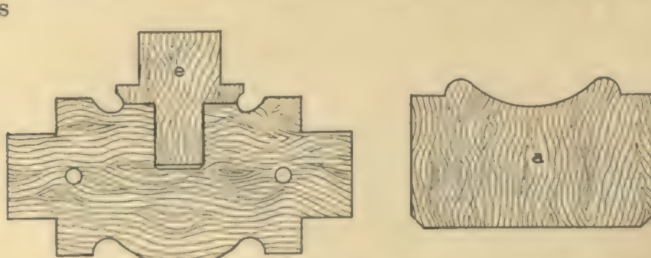


Fig. 221.

Before marking out the template, that the lines may be more readily seen, it should be cleaned with a piece of emery cloth and have a dark coating of the following solution. Dissolve an ounce of sulphate of copper in about four ounces of water and to this add one teaspoonful of nitric acid. Treat the surface of the zinc with this solution, rubbing on with a piece of waste. A thin coating of copper will thus be given to the zinc (also to steel or iron). When applied to finished surfaces they should be rubbed dry, as iron or steel will be rusted.

When the curves of the template will allow of sawing, the zinc template is easily shaped by placing a piece of zinc of the necessary size between two boards, and nailing them together. The required shape having been drawn on the upper board, the whole may be sawed to the form required on the band saw or scroll saw, but preferably on the latter, with a fine tooth narrow saw blade which will give a smoother edge to the zinc. If the boards are firm, the metal will offer no resistance whatever to the saw, nor will the saw be perceptibly dulled. For small curves, lay the zinc on a piece of hard board, and with a pair of sharp pointed dividers the zinc can be scratched half way through its thickness, then by turning it over and placing the dividers in the same center, the other side may be cut in the same way, or so nearly through that it will break off. This affords a truer and more uniform curve than can be obtained in any other way. The legs of the dividers must be stiff and firm so as to be entirely free from vibration. After cutting, the sharp edges of the zinc may be dressed with a fine double-cut file, or better with fine emery cloth or sand paper rolled over a wooden holder.

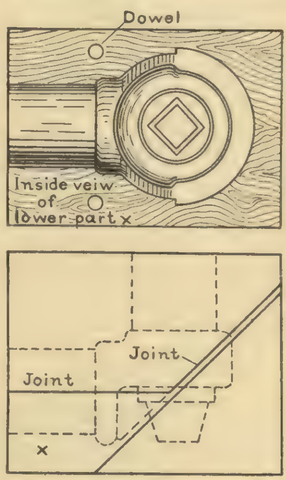


Fig. 222.

The lathe should always be stopped when testing the work with the template, and great care must be taken to make the two ends of the pattern symmetrical.

When the turning is nearly completed the template itself may be tested by reversing the ends. If not true it should be filed to the proper shape as shown by the drawing.

The branch *e* must be turned in the same way as described for the main part of the pattern which is pared off, or planed off in a large pattern, to the exact size of the base of the branch, and when the pattern is large and heavy, one or two wood screws should be used in the tenon of the branch to assist in keeping it in place.

In all small and moderate-sized valves, the flanges are hexagonal in shape as shown in Figs. 218 and 220. The core for a globe valve is made in two parts, and the core box for each part must be made in upper and lower half, making four parts to the

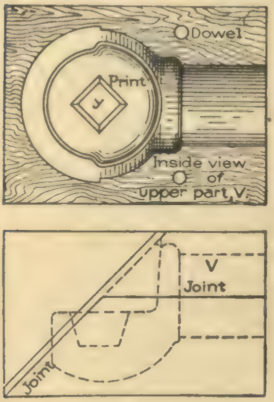


Fig. 223.

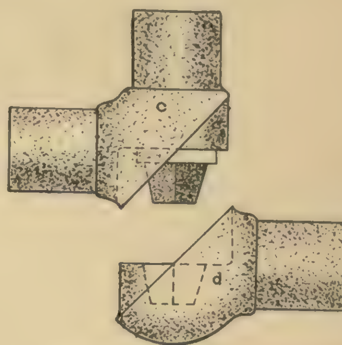


Fig. 224.

core box. This is necessary in order to allow for the removal of the core from the boxes. The internal shape of the boxes are difficult to illustrate on paper, but if the drawings given in Figs. 222 and 223 are carefully studied in connection with the sectional views of the valve shown in Fig. 219 their shape and construction should be readily understood.

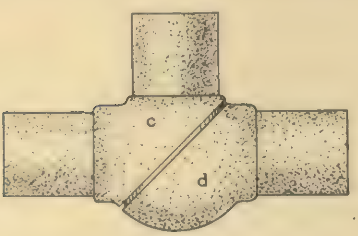


Fig. 225.

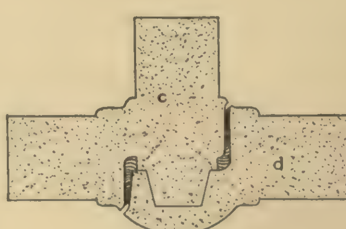


Fig. 226.

Three additional illustrations of the core as made in these boxes are shown in Figs. 224, 225 and 226.

In Fig. 222 there are two views of the box in which the upper part C of the core shown in Fig. 224 is made. This box separates along the two lines marked "Joint" (Fig. 222) and, as will be readily seen, allows the core to be easily removed when the box is opened. The lower part *d*, Fig. 224, of the core is made in the box shown in Fig. 223. The part *c* has a square tenon which fits into the mortise in the part *d*. This mortise is made in the core by means of the print marked Y in Fig. 223, and as will be seen by Fig. 224, this core tenon and mortise will bring the two parts of the core into perfect alignment when they are pasted together.

In Fig. 225, we have an outside view of the completed core and in Fig. 226 a sectional view through the middle of the core, lengthwise; from which the necessity for the tenon and mortise

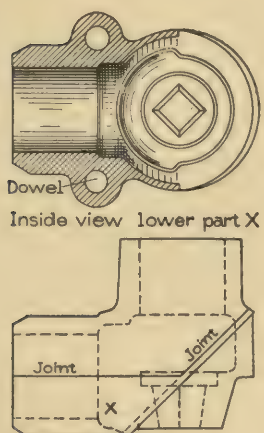


Fig. 227.

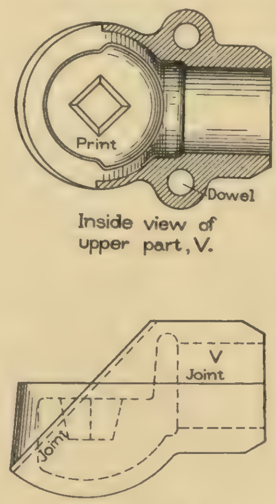


Fig. 228.

connection will be readily understood, this being the only connection between the two parts of the core. In working out the core boxes it is well to use templates which can be formed and made from the drawings furnished. The templates will aid in getting the proper shapes, and leaving a uniform amount of metal in all parts of the câse.

Figs. 222 and 223 illustrate the common wooden core box, but to insure uniformity, and because of the necessary wear and fragile character of wood for boxes of this kind, these core boxes should be made of metal. The wooden pattern for the metal core-box must then have an allowance for double shrinkage, and to avoid excessive weight, the box is made in the form shown in Figs. 227 and 228. In this form all unnecessary metal is removed and the connecting iron dowel pins are placed in lugs or thin outside projections as indicated.

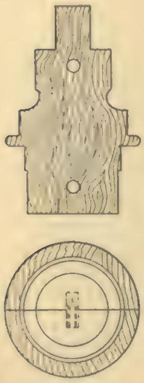


Fig. 229.

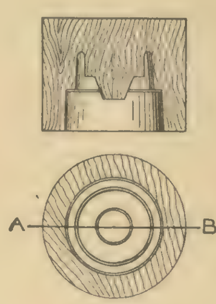


Fig. 230.

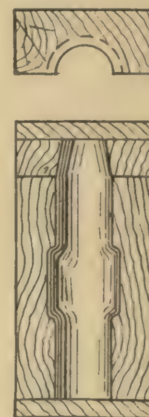


Fig. 231.

Fig. 229 illustrates the pattern for the stuffing box and bonnet of the valve, with core print turned on each end, which, like the main pattern of the valve must be parted, or made in two halves. Two core boxes are necessary to make the core for this part of the valve.

From Fig. 230 it will be seen that the core box for the lower end of the core can be turned out on the lathe by using a template of the required shape. For the upper part or stem, the half box shown in Fig. 231, is all that is necessary. By examining the two core boxes, Figs. 230 and 231, it will be seen that here again we have recourse to the tenon and socket form of construction for uniting the two parts of the core which are shown pasted together in the completed core, Fig. 232. The nut for the bonnet is shown in Fig. 233, and the pattern, which is hexagonal, should be so made as to form its own core, as indicated by the dotted lines in the drawing. Fig. 234 shows the pattern for the valve and also the pattern for the valve nut, each of which will form its own core, and Fig. 235 is an illustration of the pattern for the valve spindle.

Fig. 232.

GEAR WHEEL PATTERNS.

In this special class of pattern work, the greatest accuracy and care must be taken, not only in building up the rim of the wheel, but in fitting and placing on the rim the blocks, out of which the teeth are to be formed, and most of all in laying out

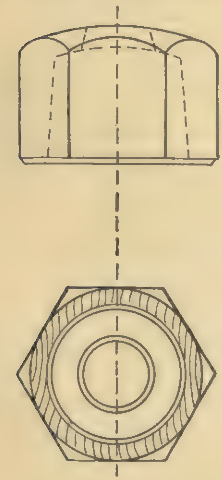


Fig. 233.

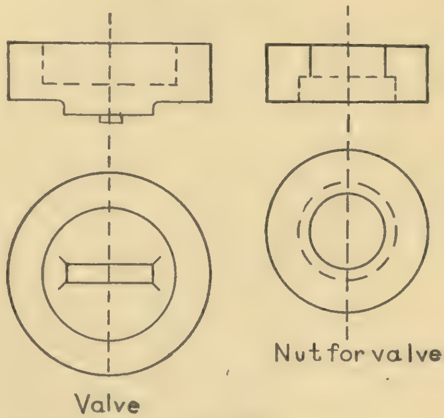


Fig. 234.

the teeth regularly and accurately on the tooth blocks. A pattern for a gear wheel, whose teeth are carelessly made is almost worthless, the time lost in chipping and filing, for the purpose of correction, being too great to allow the use of such a pattern.

Fig. 235.

To insure greater accuracy and smoother running gears, it is now the custom in many shops to have the wooden pattern made in the form of a blank, (without teeth) from which a metal pattern is cast.

This cast pattern is turned up and placed in the milling machine where the teeth are cut and spaced with accuracy and to the exact form of tooth required. This metal pattern is used without *draft*.

This method of making gear patterns, however, is expensive, and is used only when many wheels are to be cast of the same size and number of teeth from the same pattern, and, as in the case of pulleys, the wooden pattern is still used for all special sizes of gears.

For these wooden patterns we shall now give a few hints as to the best methods of construction. As the form of the tooth used by the draftsman will play no part in the construction of the pattern, we think it would be out of place here to enter into a discussion of the relative merits of the single curve, double curve, or other form of tooth.

The single curve or involute tooth, however, has the great advantage of being the only form of gear which can be run at

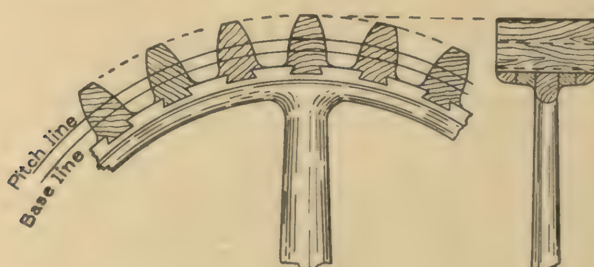


Fig. 236.

varying distances of axes, and transmit an unvarying velocity and amount of power. The common contention that two gears will crowd harder on their bearings when the single curve, or involute form is used, has not been proven in actual practice. The practical methods for obtaining the curves for either the involute or for the epicycloidal tooth, the two forms in most common use, are taken up in Mechanical Drawing.

In the illustrations here given the single curve form of tooth is used.

In the construction of gear-wheel patterns, the methods employed in making and fastening the tooth, or the blocks out of which the teeth are to be formed, to the rim of the wheel, varies greatly. It was formerly the custom to dovetail the tooth into the rim of the wheel as shown in Fig. 236. This was the case especially when the teeth were large, as in 2 pitch or larger.

This is, however, an unnecessary expense and a waste of time, and in addition, the cutting of the dovetails and the driving home of the dovetailed tooth, often have the effect of distorting the rim to some extent. A better, or at least a more economical method is to fit the tooth blocks as shown in Fig. 237, which for strength and durability is found to be in no way inferior to dovetailing, and the saving of labor and time is very great.

In this method we have always the advantage of a smooth, clean fillet at the root of each tooth, and having the grain of the wood, not only for the fillets, but also on the whole depth circle, run in the same direction as the grain of the wood which forms the tooth. This means a smoother pattern, more easily moulded, and a better casting.

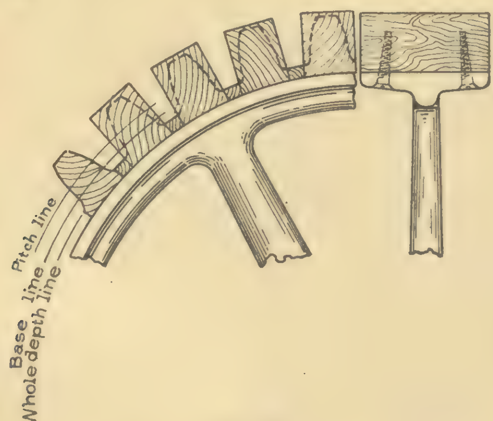


Fig. 237.

In the former method, Fig. 236, it is almost impossible to form a fillet on each side of the tooth, as it runs off to a thin feather edge which continually splinters and chips off; still further, the bottom of the tooth space, that is, the whole depth circle is the rim of the wheel, composed of layers of segments with changing grain which will not mould so smoothly as in the second method.

The blocks for the teeth should always be cut in strips two or three feet in length, in order to thoroughly season the wood, at least so far as it is possible to do so, while other parts of the wheel are being constructed.

Only straight-grained wood should be used for teeth. The segments for building up the rim should be cut out next, then the arms put together and shaped as required. It is a good plan to fasten the arms central to the face plate of the lathe, and to turn out a recess, say $\frac{1}{16}$ inch or $\frac{3}{32}$ inch deep to receive the hubs as shown in Fig. 238. This makes a stronger connection and does away with the trouble of fitting and connecting the hub, with the thin feather edge of the hub fillet, to the surface of the web of the

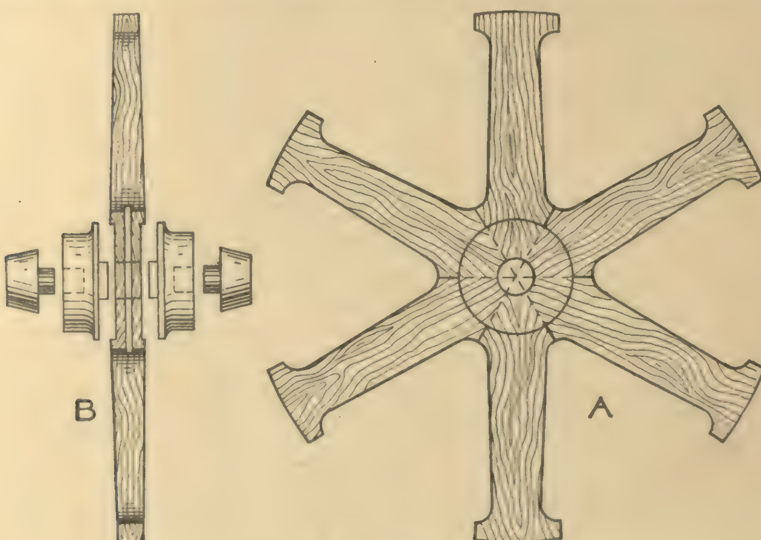


Fig. 238.

arms. The same method is of great advantage when fitting the hubs of pulleys and other wheels. The arms must be put together, with inserted tongues in the joints, as illustrated and described in Fig. 169; and if they are to be worked to an elliptical section, it is easier to do this before fixing them in the wheel. At A, Fig. 238, the construction of the arms is shown, and at B the core prints, hubs and arms, with the manner of connecting these parts.

After building up enough courses of segments to equal half the width of the rim plus half the thickness of the arms, the inside only of this part of the rim is turned out to the required shape, including the central rib *a* Fig. 239, which must be of a thickness just equal to the thickness of the ends of the arms. The recesses to receive these ends are now cut into this half rim, and the arms fitted and glued in place but not so tightly as to strain the rim and cause it to spring after it is removed from the chuck. The remaining courses for the rim are now fitted and glued on, and the rim turned and finished to the required size and shape.

The face should be glue-sized to prepare it for the blocks which are to form the teeth of the gear.

After sizing and removing the raised grain of the wood, the periphery of the wheel must be spaced for the required number

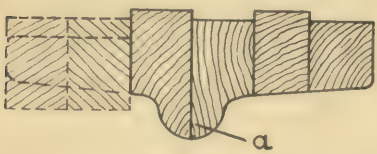


Fig. 239.

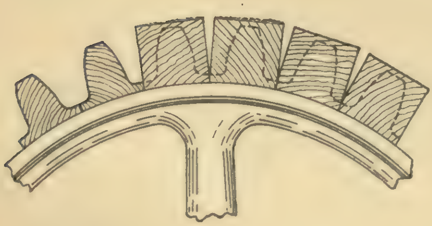


Fig. 241.

Fig. 240.

of teeth. With a try square and very sharp awl draw lines through the points obtained by the spacing as shown in Fig. 240. Should the teeth be of moderate size, say 3 pitch or less, the tooth blocks should be glued on sc as to meet each other on the rim of the wheel as shown in Fig. 241.

Each block must be so fitted as to reach only from line to line, Fig. 240, care being taken to have each block parallel to, and coincide with its own line, *reaching exactly to the line*. When all the blocks are placed and glued, the wheel is returned to the lathe and the periphery turned off straight and to the required diameter for the addendum, or extreme ends of the teeth. The ends of the blocks are also turned even with the edge of the wheel rim, and before removing from the lathe, a circular line must be drawn on the ends of the blocks, on both sides of the rim, indicating the whole depth of the teeth. The use of this line will be explained later; it is the only circular line needed for laying out, or for working out the teeth. When the teeth are large, a tooth block is first fitted on and screwed from the inside of the rim as shown in Fig. 237, one edge of the block touching, but not covering its line on the face of the rim. The thin strip is next fitted, glued and braded against the block with the opposite edge of the strip reaching just to, but not covering the next line. A second tooth block is fitted and screwed in place, then a second strip, and this alternate placing of blocks and strips continued until the surface of the rim is covered, having a block and strip for each tooth required.

Care must be taken not to allow any glue to get between the blocks and the strips when gluing and nailing the strips on, as each block must be taken off, one at a time, after being laid out, to work the tooth to shape. When all the blocks and strips are in place, the wheel must be returned to the lathe and the face of the blocks turned to the diameter required for the addendum or outer ends of the teeth, and the ends of the blocks also turned even with the rim.

The whole depth circles are marked, one on each side, while revolving in the lathe, as explained for a wheel with smaller teeth. All parts of the rim should now be made perfectly smooth with fine sand paper using a holder or block, to prevent rounding the corners or angles of the tooth blocks.

Beginning at the middle of a block, space the required number of teeth on the periphery of the tooth blocks, and should the first trial not result in even spaces, the trial spacing must be continued until the greatest accuracy has been obtained, that is, until all distances from point to point are exactly equal. Through each spacing point, found as above, very sharp but light lines are drawn across the face of the blocks, as was shown for the wheel rim in Fig. 240. When drawing these lines it will be found best to draw along the *inside* edge of the try square blade instead of the outside as is usual. The reason for this is that on small or medium sized wheels, a much firmer base will be given for holding the square, and more accurate lines will be the result. A coat of shellac brushed over the ends and faces of the blocks, if sand-papered smooth after being allowed to dry, will greatly assist in laying out the teeth, hardening the surface, and enabling sharper lines to be drawn. A template must next be made of the exact form of the tooth required. This will always be given full size in the detail drawings furnished to the pattern maker.

Should the wheel be of small diameter the template may be laid out and cut on the end of a long strip of zinc, but it is better to fasten the template to the end of a wooden bar, as shown in Fig. 242 a narrow slot having been cut through the back end of the zinc to allow of exact adjustment to the diameter of the wheel.

This wooden bar is hung centrally on a peg or dowel which must be placed exactly in the center of the hub. For this purpose

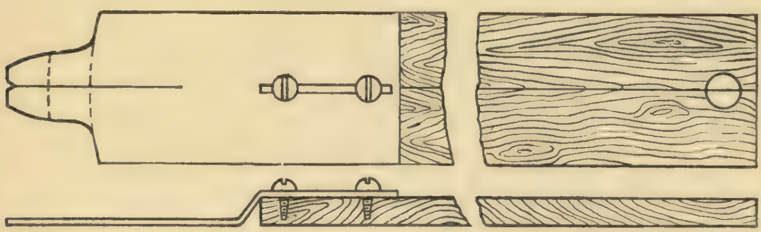


Fig. 242.

it is customary to use a block of wood as a temporary hub, the center of which may be easily found from the periphery of the blocks by the dividers. A very slight, sharp notch is made in the exact center of the end of the tooth template, which must be radial to the hole in the opposite end of the bar on which the template revolves. This notch is shown in Fig. 242.

To use the template, place it over the center pin and bring the notch exactly in line with one of the spacing lines on the outside of a block and with a very sharp pointed awl mark the tooth on the end of the block. Then swing the template to the next line and mark as before, continuing the process until a tooth has been laid out on the end of each block. The wheel is now turned over and the same process repeated on the other side. It will be readily seen that if the spacing lines have been squared across the face of the wheel with accuracy, the teeth laid out on the two sides will be true and perpendicular to each other, a spacing line forming the exact center of each tooth, and for this reason these lines should always be very light but sharp and clearly defined.

For convenience in cutting and paring, a second series of lines should now be drawn across the face of each block connecting the extreme ends of the lines which describe the shape of the tooth on each end of the block. Should the wheel be small and within the capacity of the band saw, all superfluous wood may easily be removed from between the teeth.

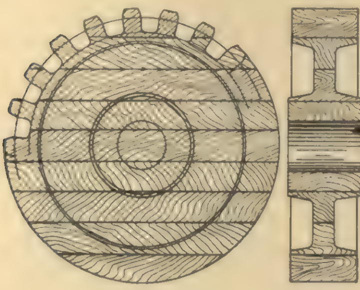


Fig. 243.

If the band saw is sharp and evenly set, and the operator skillful, the teeth may be sawed so as to need but very slight correction with the paring chisel and gouge.

As the hubs usually project beyond the rim on each side of the wheel, they should be left loose and removed before placing the wheel on the saw table.

For large wheels and heavier teeth, each tooth block should be unscrewed and removed, one at a time, and planed to the lines marked on its ends and face, after which it is returned to its place before a second one is taken off. This is continued until all the teeth are shaped, when it will be necessary only to construct fillets at the base of the teeth, and also to work each space down to the *whole depth circle*, the circle having been drawn for this purpose, and also as a guide, for bringing all tooth spaces to the same depth.

Small gears, or pinions as they are called, are usually made with a solid web instead of arms, and are glued up in solid blocks of end wood, the grain of the entire block running parallel with the face of the teeth. Such an end wood pinion is shown in Fig. 243. It is turned and the gear laid out and cut in the same way as described for the larger wheels, except that the teeth are not glued on but cut out in the solid disc. In the construction shown in Fig. 241, the teeth, not being screwed on, must be nailed with brads, *after* being shaped and finished, from the face of each tooth into the rim.

Patterns for Bevel Gears are built up as illustrated at *a*, Fig. 244, the wooden face-plate, or chuck, being provided with ten or more radial blocks as shown and described in Fig. 168. The advantage of the blocks is that they keep the first layer of segments out from the face-plate and give easier access to the back edge or angle of the rim while being turned.

The segments are usually made to overlap as shown, which is not only a saving of wood but also saves the time which would be required to turn the angular rim from a square construction. When a sufficient number of courses have been built up, the face and two edges are turned to the required angles, as indicated by the dotted lines in *a*, Fig. 244. The rib *c* which will finally be a continuation of the arms, is also turned to shape and to the thickness of the ends of the arms. The rim will then present the appearance shown at *b*, Fig. 244, except the arms which are here shown in place.

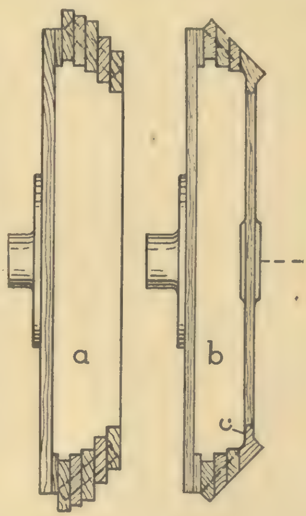


Fig. 244.

Fig. 245.

The rim is next cut from the blocks, and an angular groove turned in the face of the chuck which will fit and center the finished edge of the rim on the faceplate. In this position the inside of the rim is turned and finished as shown in Fig. 245. The rim is retained on the chuck by four or six cleats, *d*, Fig. 245, the cleats fitting over the rib *c*, Fig. 244, and preventing the rim from moving and changing its position on the chuck.

It is not necessary here to describe the method used in finding the required angles for the face and edges of the rim, but as in the case of spur-gear teeth, the student should refer to Mechanical

Drawing. The arms, partly shown in Fig. 246, in place in Fig. 244, are next fitted and fastened to the rim. It is well to glue a small disc on each side of the web of the arms as shown in Fig. 246, which not only strengthens the arms, but serves as a fillet around the hub of the wheel.

The blocks for the teeth are next fitted in place, either as illustrated in Fig, 247, or in the form of alternate blocks and strips as was shown for the spur gear, Fig. 237. After all the blocks are in place, the wheel must be put in the lathe and turned to the sizes and angles required for laying out the teeth. A sharp line must be drawn on the face of the blocks, while in the lathe, to serve as a guide for the dividers while spacing the teeth.

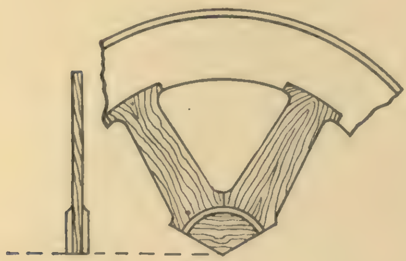


Fig. 246.

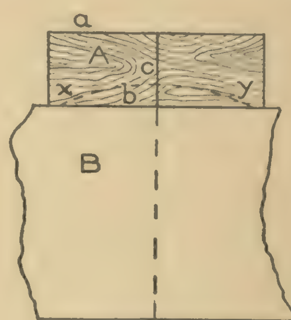


Fig. 248.

To obtain the center lines for the tooth faces after spacing on the blocks, it will be readily seen that the ordinary try square cannot be used as in the case of the spur gears. A temporary square must be made for this purpose as follows:

Take a piece of hard wood, about 6 inches long and 3½ inches wide and ½ inch in thickness. Dress the two edges perfectly parallel and from the upper edge *a*, Fig. 248, with a try square and a sharp pointed knife, draw the line *c*, equally distant from each end of A, and at right angles to the edge *a*. Lay the edge *b* of A, against another board B, of the same thickness, and continue the line *c* on this board as shown by the dotted line. With the dividers set to a radius equal to the longest radius of the outside ends of the tooth blocks, from the extended line *c* on the board B, describe the arc *x y* on A. Cut the edge *b*, to this arc and see that it fits perfectly the outer rim of the tooth block. Next make a thin blade of hard wood and screw to the head A, using the greatest care to have one edge of the blade coincide exactly with the line *c*. After screwing the blade to the head, its accuracy may be tested by placing a try square against the edge *a*. The result will be as shown in Fig. 249, in which the edge *c* is radial to the arc *x y*. This edge will describe the center lines of the teeth radially as required.

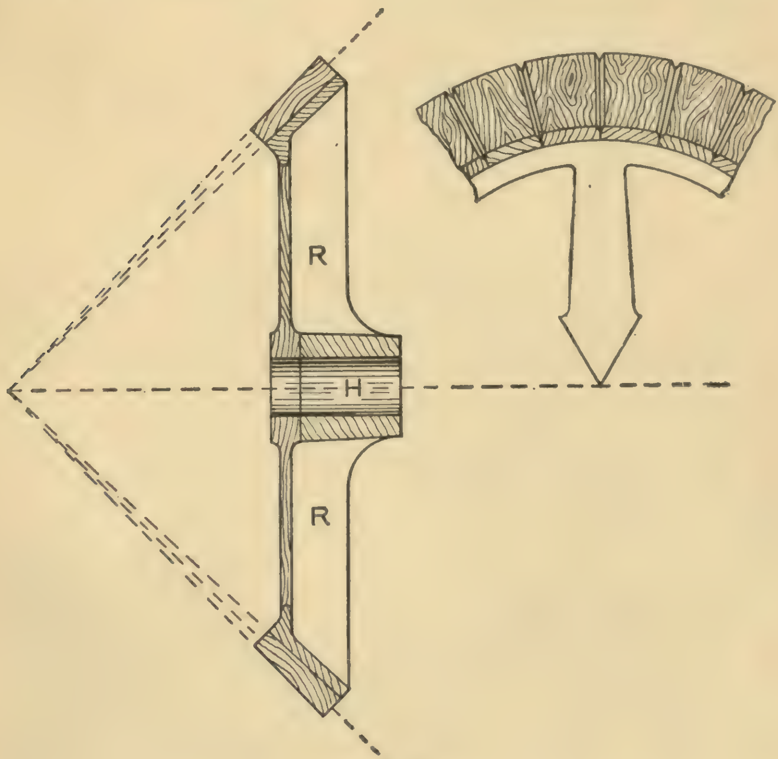


Fig. 247.

This temporary square can be used up to a certain limit, on wheels of larger diameter than that to which it has been fitted, but cannot be used for smaller wheels. For larger gears the position will be as shown in Fig. 250, which will give the correct perpendicular if the angles at *x* and *y* are carefully made. By using in this way, only a few squares will be needed for a great number of wheels. In Fig. 247 the hub H and the ribs of the arms R R. are often made loose so as to lift with the cope, which is of great advantage in moulding. When the teeth are large, they must be screwed on from the inside of the rim. If small, they should be braded from the outside, or face of the tooth, into the rim *after*

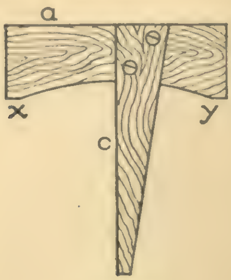


Fig. 249.

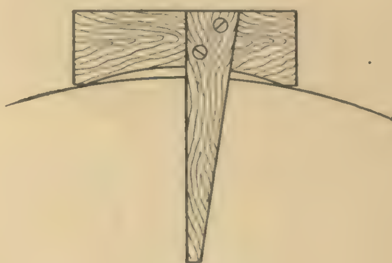


Fig. 250.

the teeth have been shaped and finished. Two templates will be necessary for laying out the ends of the teeth, the outer ends being larger than the inner. These templates are made as described for spur gears, and have the outer end bent to fit over the angles of the rim.

COLUMN PATTERNS

Cast-iron columns are often ornamented or fluted as shown in the half section of a fluted column in Fig. 251. In all such cases the body of the pattern is made octagonal as shown by the line A B C D E. The loose pieces forming the flutes are held to the main body by pins that stand at right angles to the line A E. After the sand has been rammed, the body included in the lines A B C D E is lifted out leaving the parts A *a b* B, B *b c* C, etc., imbedded in the sand. Then one after another these are lifted out.

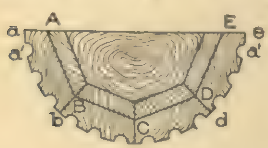


Fig. 251.

These fluted sections should never be so few in number that they cannot be lifted out without tearing the sand. Eight or twelve sections will be needed.

Other forms of ornamentation are put upon columns in a similar manner. Leaves or flowers are held by pins or in grooves in such a way that the main body of the pattern can be lifted out without disturbing them, and they are then withdrawn from the sand through the cavity left by the main pattern.

Cores for Columns. Cores for columns may be made in core boxes as in the case of those for pipe, but where the core is long and straight no core box is needed. The core is usually built of loam about an iron pipe as explained in Foundry Work.

Where the core is to follow the lines of the ornamental mouldings on the outside of the column, it may be provided with a special core box or better with a sweep as shown in Fig. 252. This sweep is used to shape the loam core that is to be built up on an iron pipe. Fig. 252 is the outline of the template that is to be used in sweeping the core for the interior of the columns shown in Fig. 253.

Fig. 252.

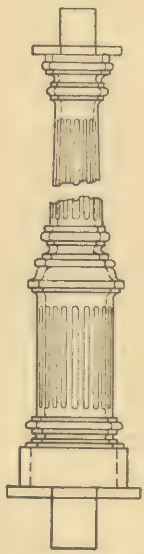


Fig. 253.

Follow Boards. All thin patterns that are likely to suffer distortion from the pressure of the sand while being rammed up, must be provided with accurately fitting follow boards. These follow boards may be made to fit on either one or other of the sides of the pattern.

When the outlines of the pattern are very irregular, the follow boards are often made of plaster or other composition, which, when dry, is used to support the pattern while the drag is being rammed.

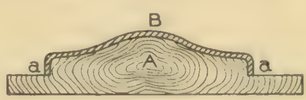


Fig. 254.

Fig. 254 represents a section of a railing cap. If the pattern B were to be set with the edges *a a* resting upon the moulding board and the sand of the drag rammed down upon its upper face, it would be sprung out of shape. To avoid this the follow board A is made to exactly fit the under side of the pattern. Then when the sand is rammed, the whole pattern is supported and there will be no distortion. When the cope is rammed the follow board is removed and the sand of the drag supports the pattern while the cope is being rammed.

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